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Hayashi et al.

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(45) **Date of Patent: Aug. 25, 2020**

(54) **SINGLE FACER**

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Jul. 18, 2014 (JP) 2014-148039

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B31F 1/28 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
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See application file for complete search history.

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(57) **ABSTRACT**

A single facer comprises: a swingable frame supporting a press roll in such a manner as to allow a gap between one of a pair of corrugating rolls and the press roll to be changed; an adjusting screw contactable with a contact member coupled to the swingable frame; an encoder for detecting vibration of the press roll occurring during formation of a corrugated medium by the pair of corrugating rolls; and a control section for controlling drive of a motor for displacing the adjusting screw. The control section is configured to execute a first control processing of driving the motor until a magnitude of the vibration is reduced to a given value.

7 Claims, 11 Drawing Sheets

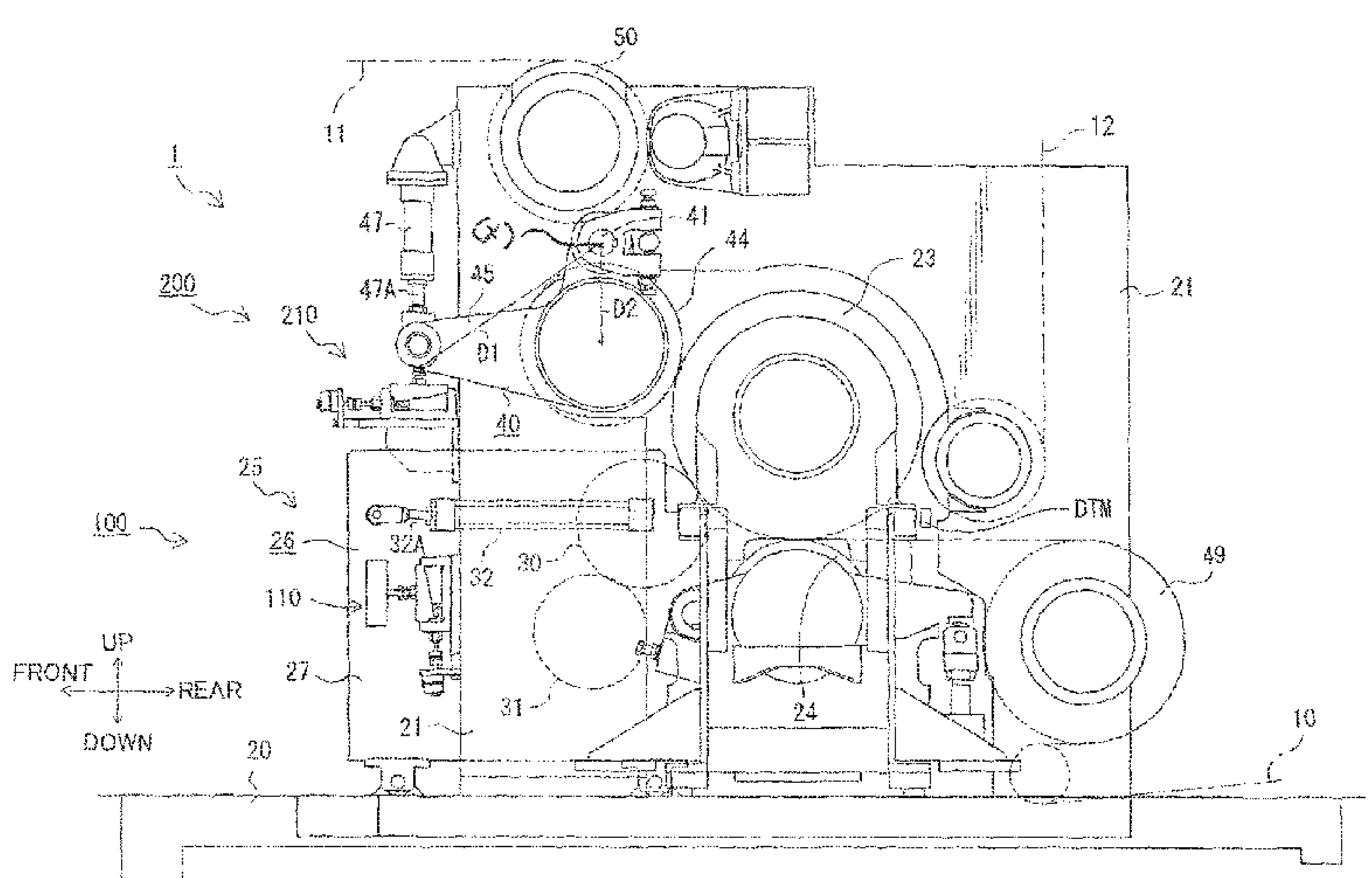
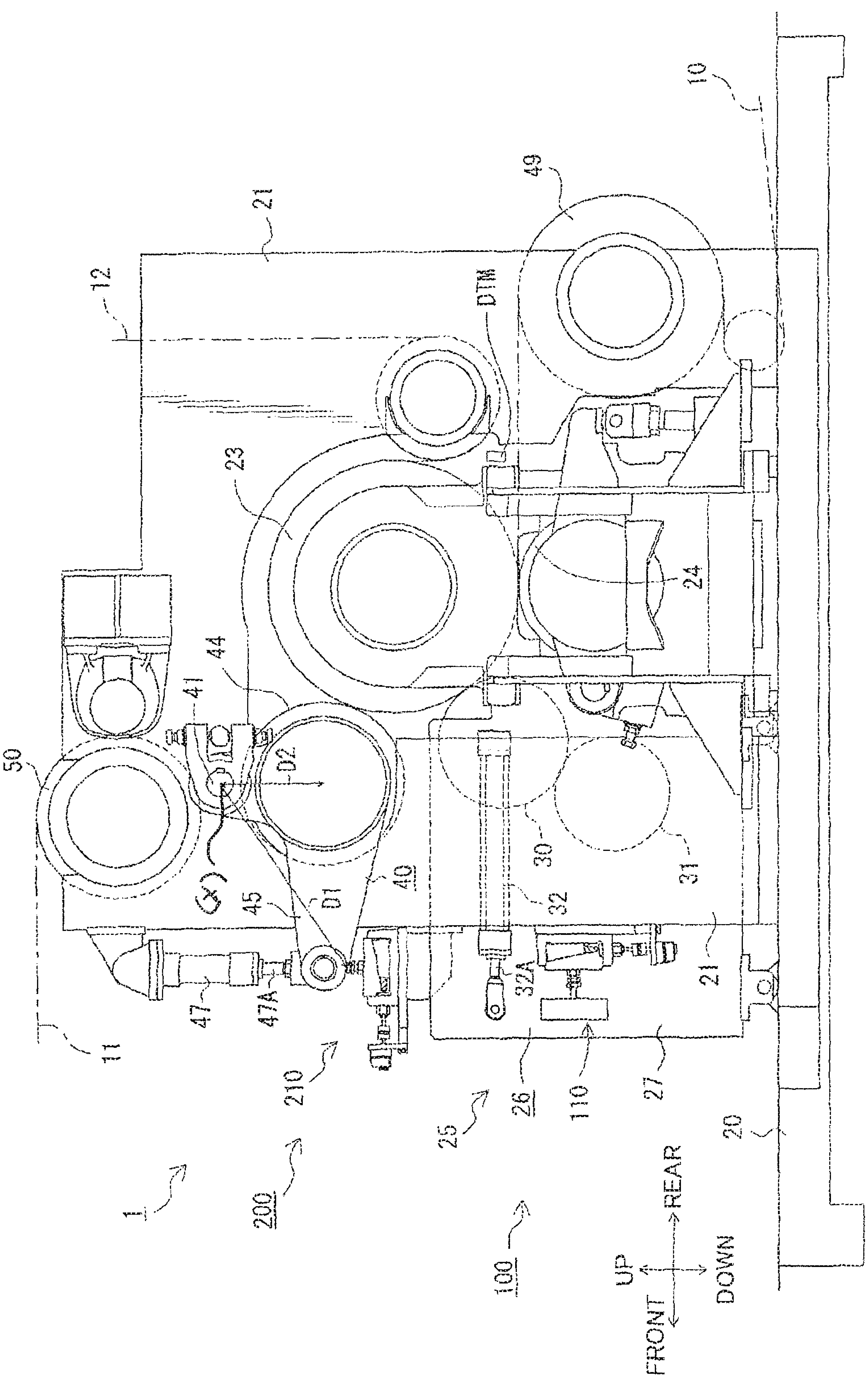


FIG.1



1
200
210
100
25
26
110
27
20
10
11
12
21
49
DTM
23
24
44
41
50
D2
D1
45
40
47
47A
30
31
32
32A
UP
DOWN
FRONT
REAR

FIG.2

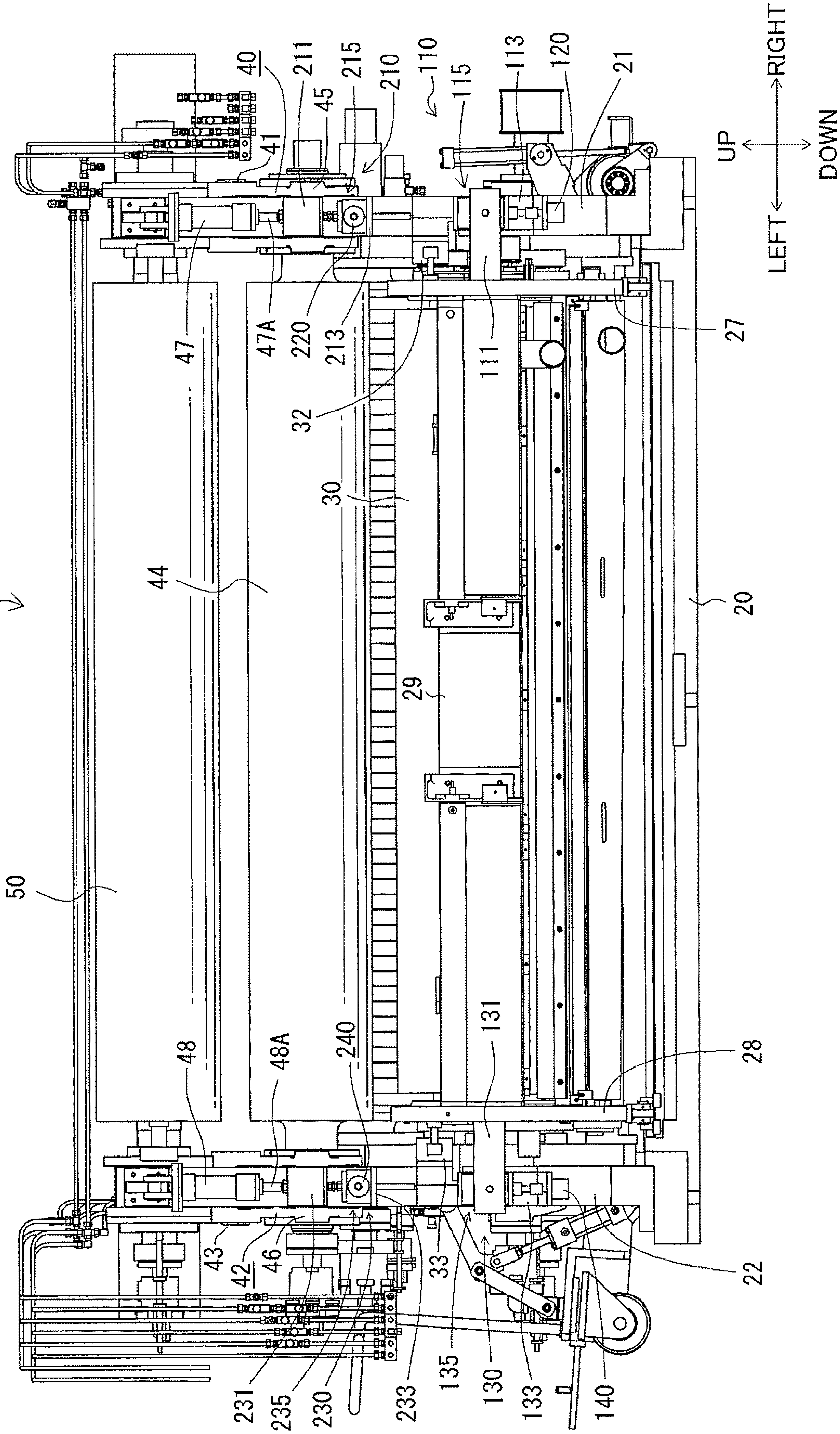
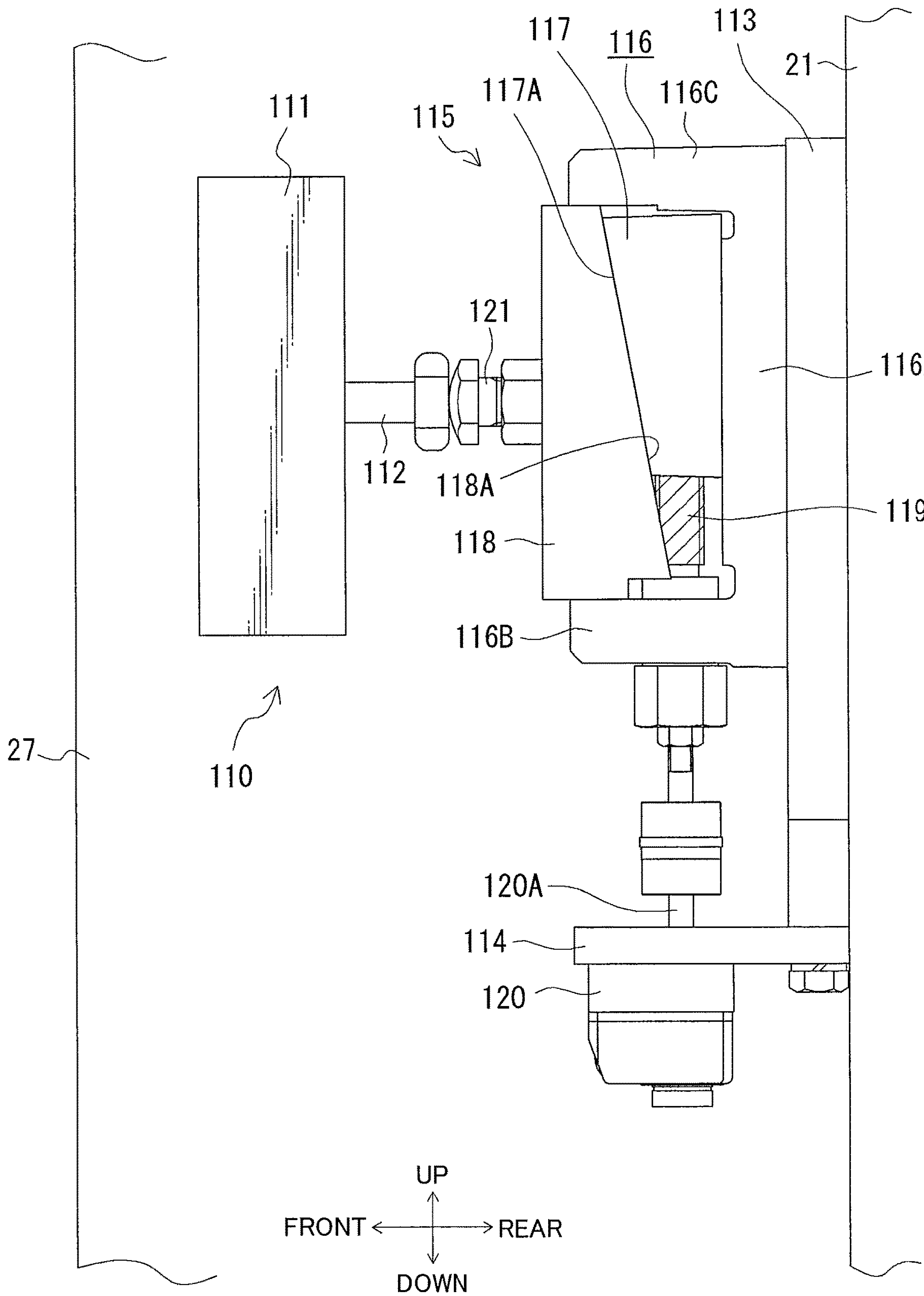
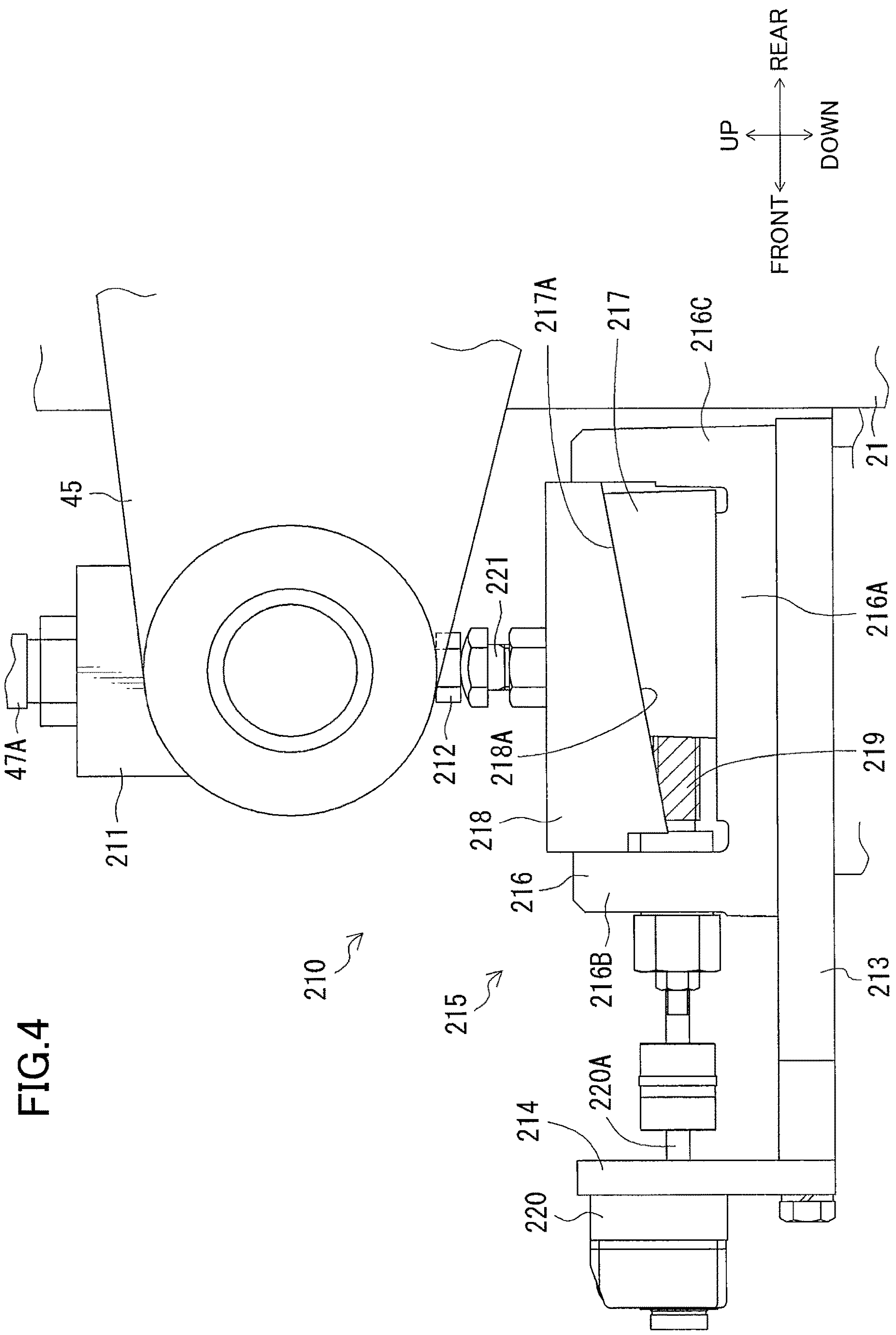

1
40
41
45
211
215
210
110
115
113
120
21
UP
DOWN
LEFT
RIGHT
47
47A
220
213
111
27
32
30
44
50
29
20
48
48A
240
131
28
43
42
46
33
22
231
235
230
233
135
130
133
140

FIG.3



117
116
113
21
117A
116C
111
115
121
116A
112
118A
119
118
116B
27
110
120A
114
120
UP
FRONT
REAR
DOWN



REAR
UP
DOWN
FRONT
217A
217
216C
21
45
221
216A
47A
212
218A
219
211
218
216
210
216B
213
215
220A
214
220

FIG.4

FIG.5

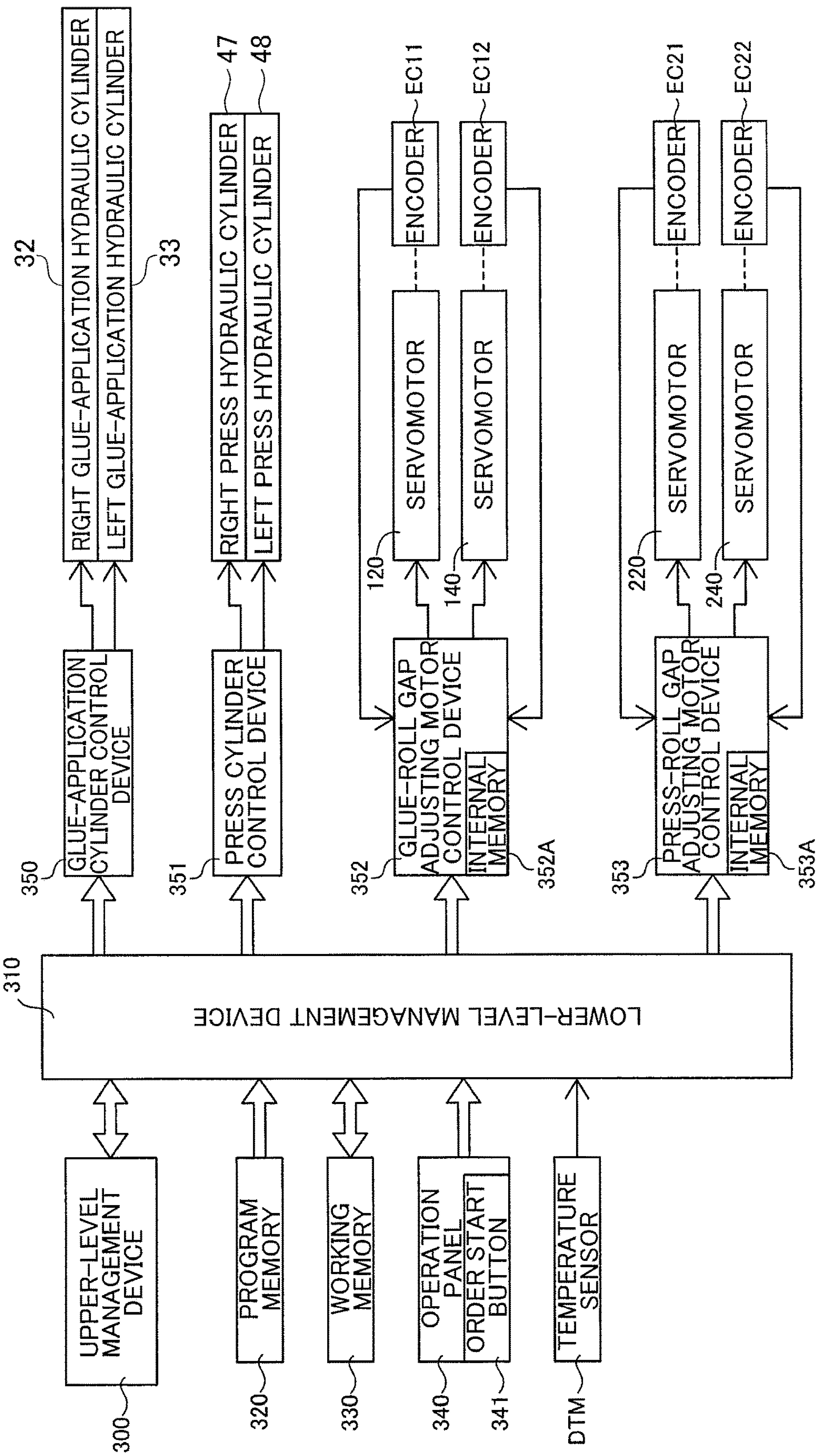

UPPER-LEVEL MANAGEMENT DEVICE
300
PROGRAM MEMORY
320
WORKING MEMORY
330
OPERATION PANEL
340
ORDER START BUTTON
341
TEMPERATURE SENSOR
DTM
LOWER-LEVEL MANAGEMENT DEVICE
310
GLUE-APPLICATION CYLINDER CONTROL DEVICE
350
PRESS CYLINDER CONTROL DEVICE
351
GLUE-ROLL GAP ADJUSTING MOTOR CONTROL DEVICE
352
INTERNAL MEMORY
352A
PRESS-ROLL GAP ADJUSTING MOTOR CONTROL DEVICE
353
INTERNAL MEMORY
353A
RIGHT GLUE-APPLICATION HYDRAULIC CYLINDER
32
LEFT GLUE-APPLICATION HYDRAULIC CYLINDER
33
RIGHT PRESS HYDRAULIC CYLINDER
47
LEFT PRESS HYDRAULIC CYLINDER
48
SERVOMOTOR
120
SERVOMOTOR
140
SERVOMOTOR
220
SERVOMOTOR
240
ENCODER
EC11
ENCODER
EC12
ENCODER
EC21
ENCODER
EC22

FIG.6

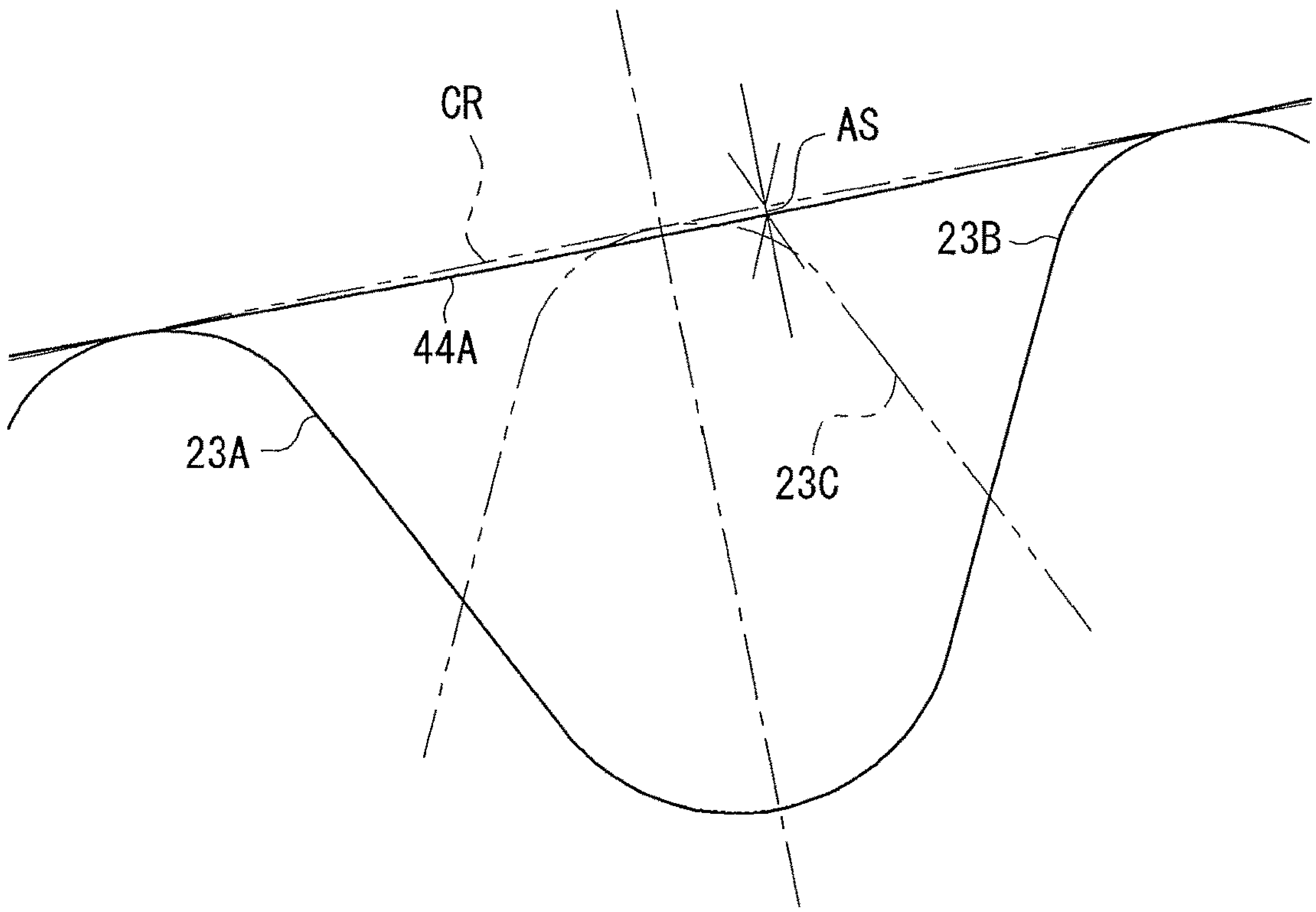

CR
AS
23B
44A
23A
23C

FIG.7

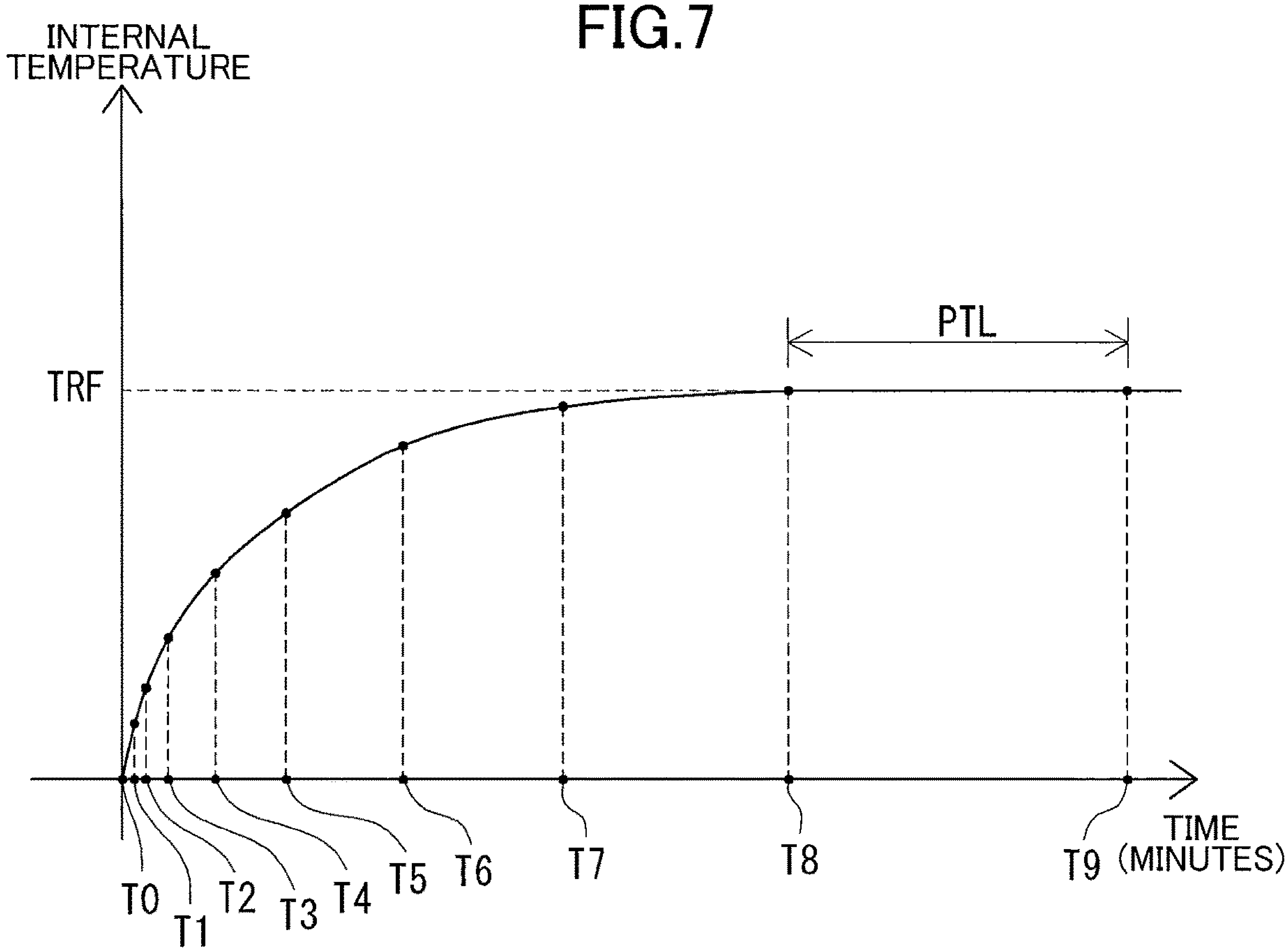

INTERNAL TEMPERATURE
PTL
TRF
TIME (MINUTES)
T0
T1
T2
T3
T4
T5
T6
T7
T8
T9

FIG.8

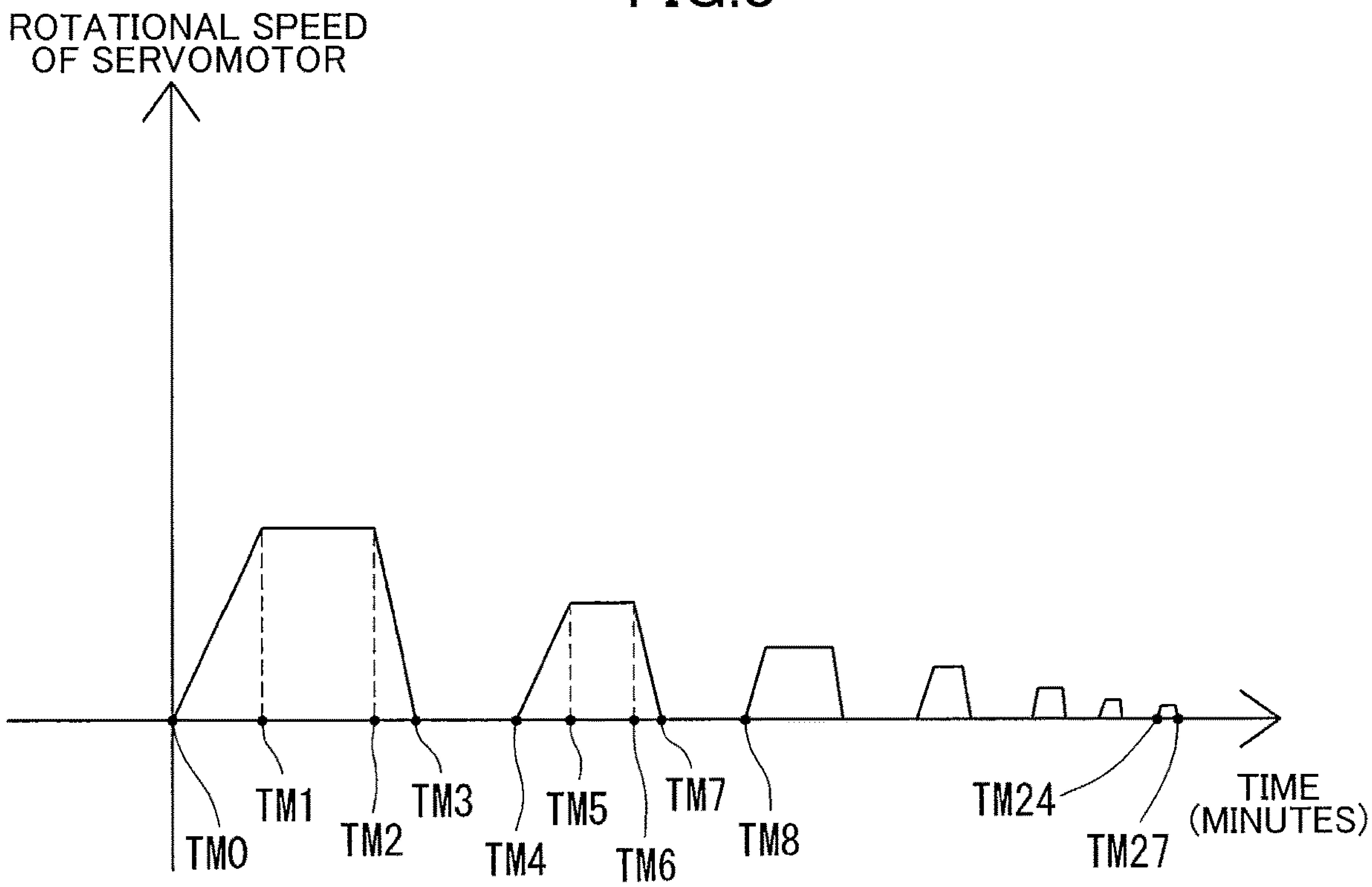

ROTATIONAL SPEED
OF SERVOMOTOR
TM0
TM1
TM2
TM3
TM4
TM5
TM6
TM7
TM8
TM24
TM27
TIME
(MINUTES)

FIG.9

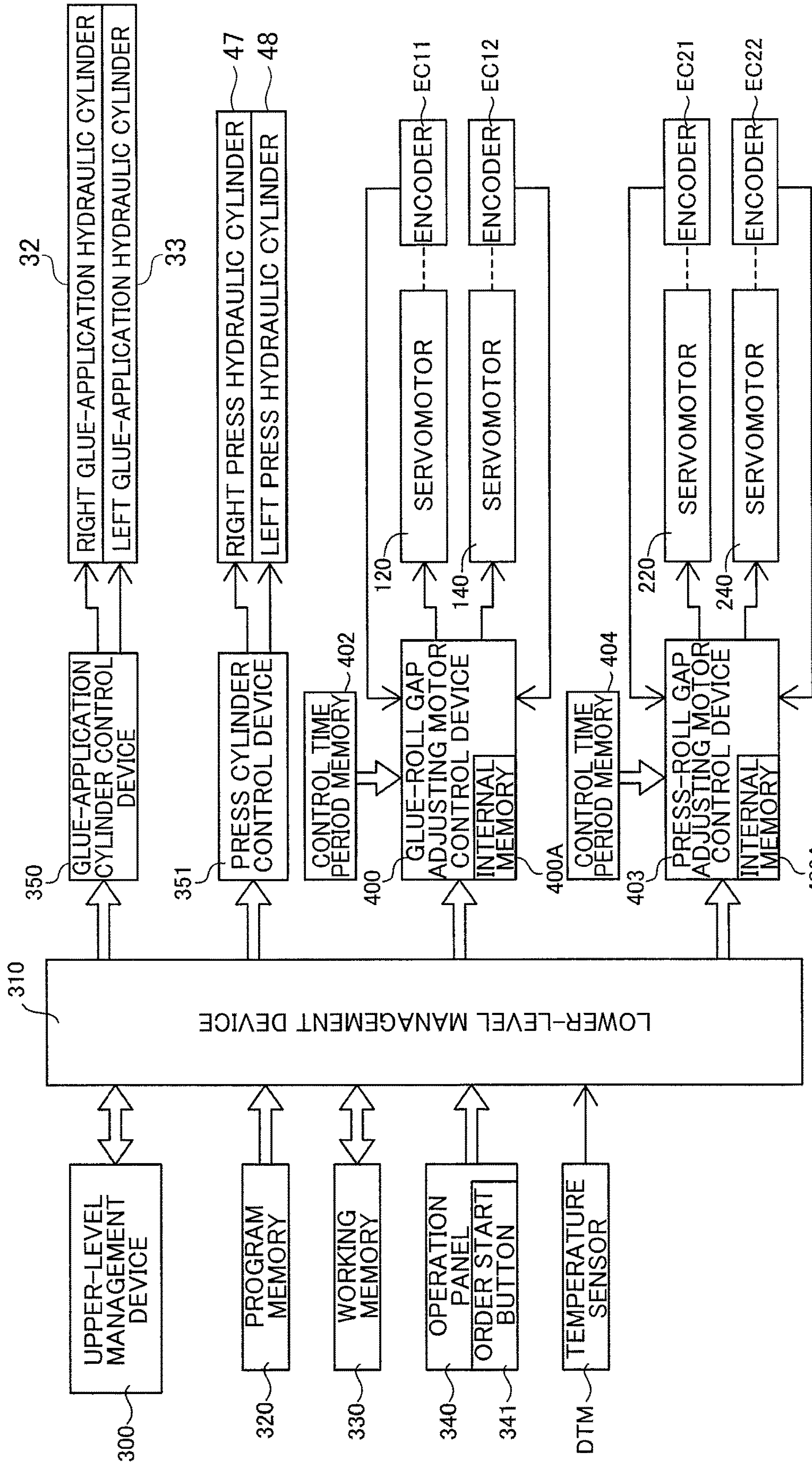

UPPER-LEVEL MANAGEMENT DEVICE
300
PROGRAM MEMORY
320
WORKING MEMORY
330
OPERATION PANEL
340
ORDER START BUTTON
341
TEMPERATURE SENSOR
DTM
LOWER-LEVEL MANAGEMENT DEVICE
310
GLUE-APPLICATION CYLINDER CONTROL DEVICE
350
PRESS CYLINDER CONTROL DEVICE
351
CONTROL TIME PERIOD MEMORY
402
GLUE-ROLL GAP ADJUSTING MOTOR CONTROL DEVICE
400
INTERNAL MEMORY
400A
CONTROL TIME PERIOD MEMORY
404
PRESS-ROLL GAP ADJUSTING MOTOR CONTROL DEVICE
403
INTERNAL MEMORY
403A
RIGHT GLUE-APPLICATION HYDRAULIC CYLINDER
32
LEFT GLUE-APPLICATION HYDRAULIC CYLINDER
33
RIGHT PRESS HYDRAULIC CYLINDER
47
LEFT PRESS HYDRAULIC CYLINDER
48
SERVOMOTOR
120
ENCODER
EC11
SERVOMOTOR
140
ENCODER
EC12
SERVOMOTOR
220
ENCODER
EC21
SERVOMOTOR
240
ENCODER
EC22

FIG.10

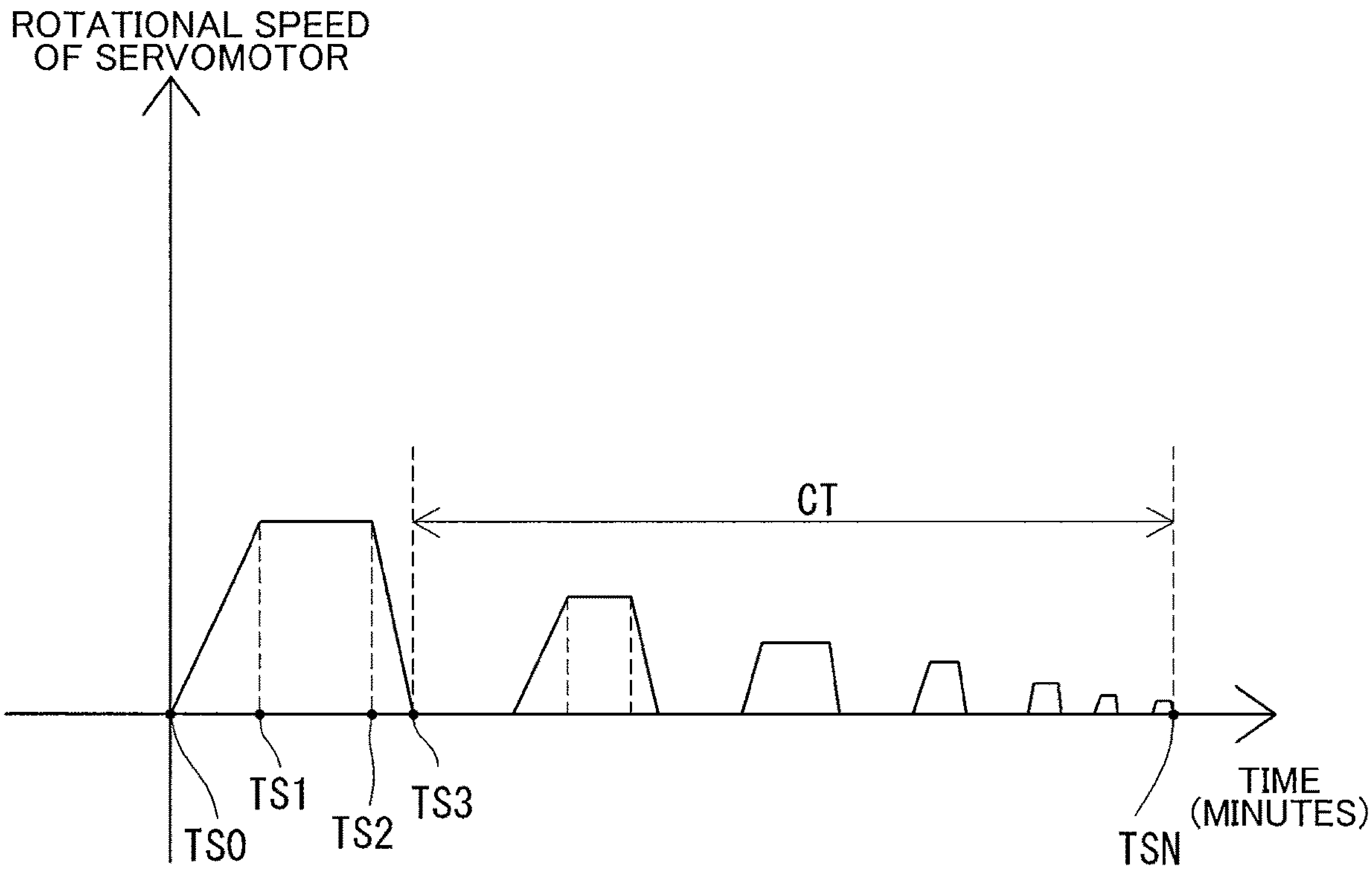
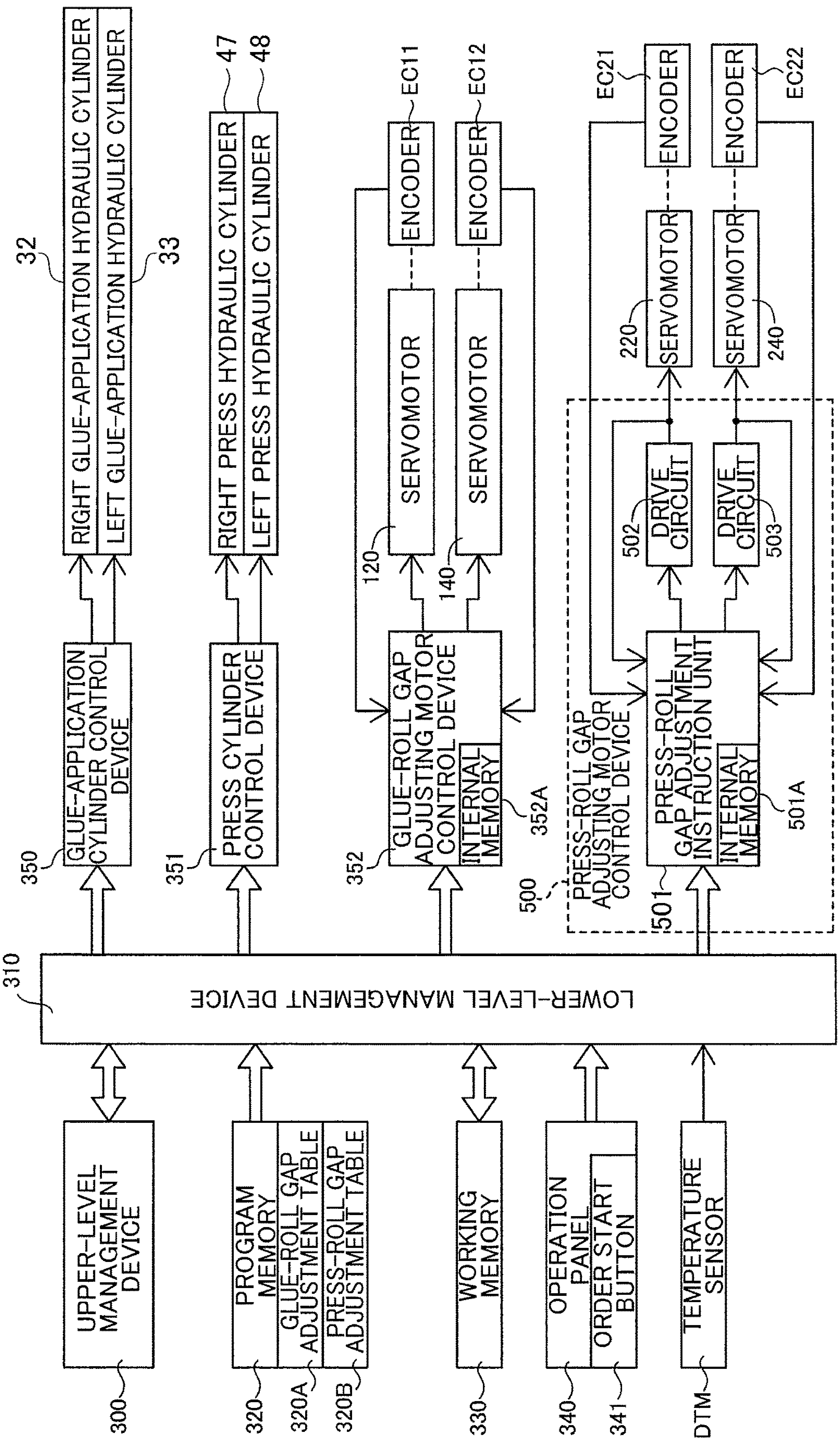

ROTATIONAL SPEED
OF SERVOMOTOR
CT
TS0
TS1
TS2
TS3
TSN
TIME
(MINUTES)

FIG.11



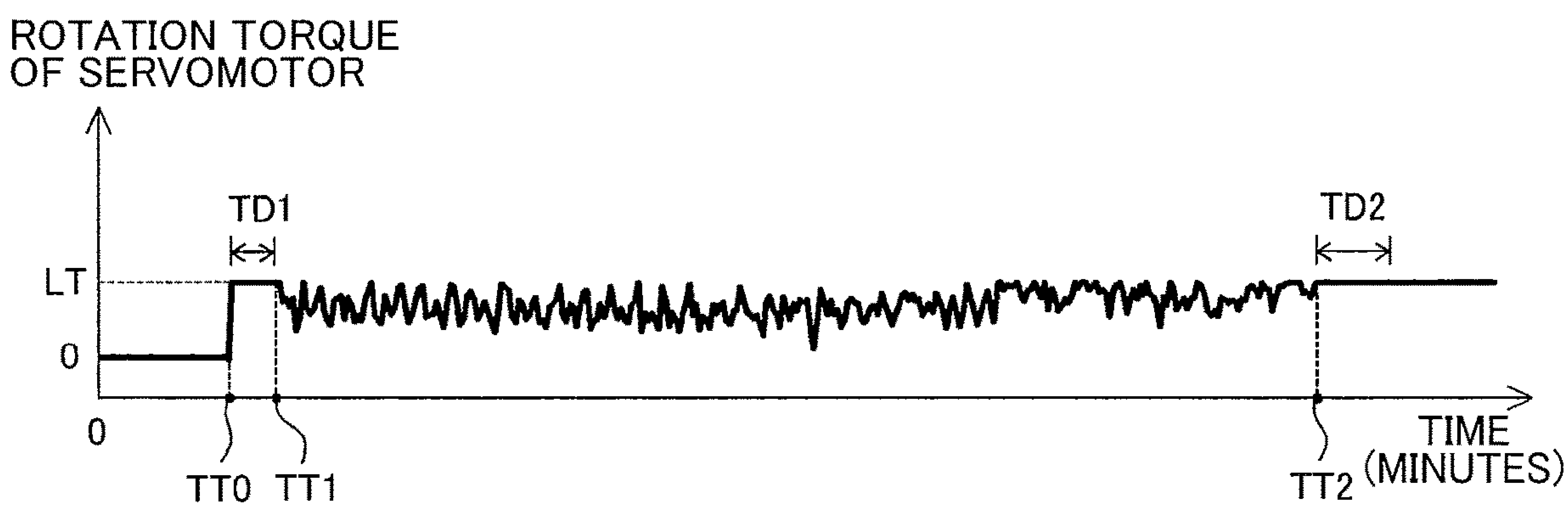
UPPER-LEVEL MANAGEMENT DEVICE
300
PROGRAM MEMORY
320
GLUE-ROLL GAP ADJUSTMENT TABLE
320A
PRESS-ROLL GAP ADJUSTMENT TABLE
320B
WORKING MEMORY
330
OPERATION PANEL
340
ORDER START BUTTON
341
TEMPERATURE SENSOR
DTM
LOWER-LEVEL MANAGEMENT DEVICE
310
GLUE-APPLICATION CYLINDER CONTROL DEVICE
350
PRESS CYLINDER CONTROL DEVICE
351
GLUE-ROLL GAP ADJUSTING MOTOR CONTROL DEVICE
352
INTERNAL MEMORY
352A
PRESS-ROLL GAP ADJUSTING MOTOR CONTROL DEVICE
500
PRESS-ROLL GAP ADJUSTMENT INSTRUCTION UNIT
501
INTERNAL MEMORY
501A
RIGHT GLUE-APPLICATION HYDRAULIC CYLINDER
32
LEFT GLUE-APPLICATION HYDRAULIC CYLINDER
33
RIGHT PRESS HYDRAULIC CYLINDER
47
LEFT PRESS HYDRAULIC CYLINDER
48
SERVOMOTOR
120
SERVOMOTOR
140
ENCODER
EC11
ENCODER
EC12
DRIVE CIRCUIT
502
DRIVE CIRCUIT
503
SERVOMOTOR
220
SERVOMOTOR
240
ENCODER
EC21
ENCODER
EC22

FIG.12

320A

BASIS WEIGHT OF LINERBOARD (g/m²) / BASIS WEIGHT OF CORRUGATED MEDIUM (g/m²)	0 ~120	121~160	161~180	181~200	201~
0 ~ 120	D11	D21	D31	D41	D51
121 ~ 160	D12	D22	D32	D42	D52
161 ~ 180	D13	D23	D33	D43	D53
181 ~ 200	D14	D24	D34	D44	D54
201 ~	D15	D25	D35	D45	D55

FIG.13



SINGLE FACER

RELATED APPLICATIONS

This application claims priority under 35 U.S.C. § 119 to Japanese Patent Application Nos. 2013-182625 filed on Sep. 3, 2013 and 2014-148039 filed on Jul. 18, 2014, the entire contents of which are hereby incorporated by reference.

TECHNICAL FIELD

The present invention relates to a single facer for producing a single-faced corrugated paperboard by forming a corrugated medium and gluing a linerboard onto the corrugated medium. More specifically, the present invention relates to a single facer comprising a gap adjusting mechanism for adjusting a gap between a press or glue roll and a corrugating roll.

BACKGROUND ART

Heretofore, there has been known a gap adjusting mechanism usable in a single facer to adjust a gap between a press or glue roll and a corrugating roll. For example, a gap adjusting mechanism for a single facer described in JP 58-042025 B (Patent Document 1) comprises: a pair of wedges each having a respective one of two oppositely-tapered surfaces engageable with each other; a gap adjustment shaft to which one of the wedges is fixed; and a motor for moving the gap adjustment shaft in its axial direction to change an engagement position between the oppositely-tapered surfaces of the wedges. The other wedge is fixed to a side plate of a pressure arm supporting a press roll. The press roll is rotatably supported in an eccentric hole of a circular bearing metal of the pressure arm. An air cylinder is coupled to the side plate of the pressure arm, in such a manner as to allow the other wedge to come into engagement with the one wedge, when it is activated.

The motor for moving the gap adjustment shaft in the axial direction is controlled by a comparison between a signal indicative of a thickness of a paperboard for a corrugated medium and a thickness of a paperboard for a linerboard, and a gap detection signal indicative of a gap between the press roll and a corrugating roll. According to the motor control, the gap adjustment shaft is moved in the axial direction to change the engagement position between the wedges, so that the gap between the press roll and the corrugating roll can be adjusted. In this specification, a thickness of a paperboard for a corrugated medium and a thickness of a paperboard for a linerboard will be simply described, respectively, as "a thickness of a corrugated medium" and "a thickness of a linerboard".

SUMMARY OF THE INVENTION

Technical Problem

When a medium is nipped between a pair of corrugating rolls and thus formed into a corrugated medium, a press roll is pressed against a specific one of the corrugating rolls through the corrugated medium and a linerboard, and a glue roll is pressed against the specific corrugating roll through the corrugated medium. Along with rotation of the specific corrugating roll, each of the press roll and the glue roll periodically comes into contact with one or more ridges of a fluted portion of the specific corrugating roll, so that the periodic contacts cause vibration in each of the press roll and the glue roll.

For example, as regards the press roll, due to the vibration of the press roll, a gap detection signal indicative of a gap between the press roll and the specific corrugating roll continually changes according to the vibration. In the case where the motor described in the Patent Document 1 is controlled based on such a continually-changing gap detection signal, the gap between the press roll and the specific corrugating roll fluctuates under an influence of the vibration of the press roll. Thus, in a region between the press roll and the specific corrugating roll, there arises a problem of being unable to stably apply a nip pressure appropriate to a combination of respective thicknesses of the corrugated medium and the linerboard, to the corrugated medium and the linerboard. Similarly, in a region between the glue roll and the specific corrugating roll, there arises a problem of being unable to stably apply a nip pressure appropriate to a thickness of the corrugated medium, to the corrugated medium.

It is therefore an object of the present invention to provide a single facer capable of, in a region between an processing roll and a corrugating roll, stably applying a nip pressure appropriate to a combination of respective thicknesses of a corrugated medium and a linerboard, to the corrugated medium and the linerboard, or stably applying a nip pressure appropriate to a thickness of the corrugated medium, to the corrugated medium.

Solution to Technical Problem

First Aspect of the Present Invention and Preferred Embodiments Thereof

In order to achieve the above object, according to the first aspect of the present invention, there is provided a single facer for producing a single-faced corrugated paperboard by forming a corrugated medium and gluing a linerboard onto the corrugated medium. The single facer comprises: a pair of corrugating rolls configured to form the corrugated medium; a processing roll configured to be brought into contact with a specific one of the corrugating rolls through the corrugated medium and the linerboard or through the corrugated medium so as to perform a given processing; a supporting mechanism supporting the processing roll in such a manner as to allow a gap between the specific corrugating roll and the processing roll to be changed, wherein at least a part of the supporting mechanism is configured to be movable to cause a change in the gap; a pressing actuator section configured to press the processing roll against the specific corrugating roll through the corrugated medium and the linerboard or through the corrugated medium; a restricting mechanism comprising a restriction member disposed in contactable relation to the movable part of the supporting mechanism, wherein the restricting mechanism is configured to allow the restriction member to be displaced with respect to the movable part of the supporting mechanism; a motor configured to be driven so as to displace the restriction member; and a control section for controlling the drive of the motor, wherein the control section is configured to execute a first control processing of driving the motor until a magnitude of vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls is reduced to a given value.

In the first aspect of the present invention, the restricting mechanism restricts a movement of the supporting mechanism by causing the restriction member to come into contact with the movable part of the supporting mechanism. The control section executes a first control processing of driving the motor until a magnitude of vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls is reduced to a given value. Thus, through the first control processing, the gap between the processing roll and the specific corrugating roll is set to a reference value free from influence of the vibration of the processing roll, so that it becomes possible to apply a stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium.

In the present invention, the processing roll may be any type of roll, as long as it is capable of being brought into contact with the specific corrugating roll. Examples of the processing roll include a glue roll configured to be brought into contact with the specific corrugating roll through the corrugated medium, and a press roll configured to be brought into contact with the specific corrugating roll through the corrugated medium and the linerboard.

In the present invention, the supporting mechanism may have any configuration, as long as the configuration is capable of supporting the processing roll in such a manner as to allow the gap between the specific corrugating roll and the processing roll to be changed. For example, the supporting mechanism may be composed of one mechanism integrally formed to support both opposite ends of a rotary shaft of the processing roll, or may be composed of two independent mechanisms each configured to support a respective one of the opposite ends of the rotary shaft of the processing roll. Further, the movable part of the supporting mechanism may be a swingingly-movable part, or may be a linearly-movable part.

In the present invention, the restricting mechanism may have any configuration, as long as the configuration is capable of allowing the restriction member to be displaced with respect to the movable part of the supporting mechanism. For example, the restricting mechanism may have a configuration comprising a rotationally-movable eccentric ring, or may have a configuration comprising a pair of relatively-slidingly-movable inclined surfaces, or may have a combination of these configurations.

In the present invention, as a technique of recognizing that the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls is reduced to the given value, it is conceivable to employ a technique of determining that a magnitude of vibration detected by the detection device is reduced to a given value. Alternatively, as the technique of recognizing that the magnitude of the vibration occurring in the processing roll is reduced to the given value, it is also conceivable to employ a technique of preliminarily and experimentally measuring a time period during which the motor is driven to displace the restriction member located at a given position spaced apart from the movable part of the supporting mechanism, toward the movable part, until the magnitude of the vibration occurring in the processing roll is reduced to the given value, and determining that an actual motor drive time period becomes the pre-measured time period.

In the present invention, the given value to be compared to the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls is a value sufficiently less than a thickness of the corrugated medium. Specifically, when the restriction member comes into contact with the movable part of the supporting mechanism, the magnitude of the vibration occurring in the processing roll is suppressed. The given value is equal to or close to the smallest value of the magnitude of the suppressed vibration.

In the present invention, the control section may be configured to controllably drive the motor until the vibration magnitude is reduced to the given value, to set the gap between the specific corrugating roll and the processing roll, at this time, or may be configured to controllably drive the motor until the vibration magnitude is reduced to the given value, and then further controllably drive the motor to allow the gap to be changed by a given adjustment value.

In a specific preferred embodiment of the first aspect of the present invention, the control section is configured to further execute a second control processing of, on the basis of a reference position defined as a position of the restriction member at a time when the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, driving the motor to allow the gap to be changed by a given adjustment value.

In the preferred embodiment having the above feature, the control section executes the first control processing of driving the motor until the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls is reduced to the given value. The control section further executes a second control processing of, on the basis of a reference position defined as a position of the restriction member at a time when the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, driving the motor to allow the gap to be changed by a given adjustment value. Thus, through the first control processing, the gap between the processing roll and the specific corrugating roll is set to the reference value free from influence of the vibration of the processing roll once, and then, through the second control processing, the gap is set to a final value by changing the reference value by the given adjustment value, so that it becomes possible to apply a stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium.

In this preferred embodiment, the control section may be configured to execute the second control processing in such a manner as to drive the motor to allow the gap to be increased by a given adjustment value, or may be configured to execute the second control processing in such a manner as to drive the motor to allow the gap to be reduced by a given adjustment value.

In a specific preferred embodiment of the first aspect of the present invention, the processing roll is made of a metal material, and the given adjustment value is determined based on a combination of respective thicknesses of the corrugated medium and the linerboard or based on a thickness of the corrugated medium, and wherein the control section is configured to execute the second control processing in such a manner as to, on the basis of a reference position defined as the position of the restriction member at the time when the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, drive the motor to allow the gap to be increased by the given adjustment value.

In the preferred embodiment having the above feature, the processing roll is made of a metal material, and the given adjustment value is determined based on a combination of respective thicknesses of the corrugated medium and the linerboard or based on a thickness of the corrugated medium. The control section executes the second control processing in such a manner as to, on the basis of a reference position defined as the position of the restriction member at the time when the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, drive the motor to allow the gap to be increased by the given adjustment value. Thus, through the first control processing, the gap between the processing roll and the specific corrugating roll is set to the reference value free from influence of the vibration of the processing roll once, and then, through the second control processing, the gap is set to a final value by increasing the reference value by the given adjustment value, so that it becomes possible to apply a stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium.

In this preferred embodiment, the given adjustment value determined based on a combination of respective thicknesses of the corrugated medium and the linerboard or based on a thickness of the corrugated medium may be preliminarily stored in a storage device in correlated relation with a thickness of each paperboard, or may be calculated based on a thickness of each paperboard. Generally, a thickness of a paperboard becomes larger along with an increase in basis weight of the paperboard. Thus, a basis weight of a paperboard may be deemed as a property relevant to a thickness of the paperboard, and therefore the above given adjustment value may be determined based on a basis weight of the paperboard.

In a specific preferred embodiment of the first aspect of the present invention, the control section is configured to execute the first control processing in such a manner as to drive the motor with a first torque for displacing the restriction member toward the movable part of the supporting mechanism by a force less than a force by which the pressing actuator section can press the processing roll against the specific corrugating roll, and then after rotation of the motor is first stopped when the restriction member comes into contact with the movable part of the supporting mechanism, successively drive the motor with the first torque until the magnitude of the vibration occurring in the processing roll is reduced to the given value, and to execute the second control processing in such a manner as to drive the motor to allow the gap to be increased by the given adjustment value, with a second torque for displacing the restriction member against the movable part of the supporting mechanism by a force greater than the force by which the pressing actuator section can press the processing roll against the specific corrugating roll.

In the preferred embodiment having the above feature, the control section executes the first control processing in such a manner as to drive the motor with a first torque, and, after rotation of the motor is first stopped, successively drive the motor with the first torque until the magnitude of the vibration is reduced to the given value. Then, the control section executes the second control processing in such a manner as to drive the motor with a second torque to allow the gap to be increased by the given adjustment value. Thus, it is not necessary to detect the vibration of the processing roll while the drive of the motor is controlled by the control section, so that it becomes possible to avoid complication of control processing to be executed by the control section.

In a specific preferred embodiment of the first aspect of the present invention, the given adjustment value determined based on the combination of respective thicknesses of the corrugated medium and the linerboard or based on the thickness of the corrugated medium is a value obtained by subtracting a total thickness of the corrugated medium and the linerboard in a compressed state under a predetermined compression force which is required for compressing the corrugated medium and the linerboard until the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, from a total thickness of the corrugated medium and the linerboard in an uncompressed state, or a value obtained by subtracting a thickness of the corrugated medium in a compressed state under a predetermined compression force which is required for compressing the corrugated medium until the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, from a thickness of the corrugated medium in an uncompressed state.

In the preferred embodiment having the above feature, the given adjustment value determined based on the combination of respective thicknesses of the corrugated medium and the linerboard or based on the thickness of the corrugated medium is a value obtained by subtracting a total thickness of the corrugated medium and the linerboard in a compressed state under a predetermined compression force which is required for compressing the corrugated medium and the linerboard until the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, from a total thickness of the corrugated medium and the linerboard in an uncompressed state, or a value obtained by subtracting a thickness of the corrugated medium in a compressed state under a predetermined compression force which is required for compressing the corrugated medium until the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, from a thickness of the corrugated medium in an uncompressed state. Thus, the reference value of the gap is set based on the combination of respective thicknesses of the corrugated medium and the linerboard each compressed by the predetermined compression force or the thickness of the corrugated medium compressed by the predetermined compression force, so that it becomes possible to apply a stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium.

In this preferred embodiment, the predetermined compression force for compressing the corrugated medium and the linerboard until the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, or the predetermined compression force for compressing the corrugated medium until the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, is a compression force set through experiment.

In a specific preferred embodiment of the first aspect of the present invention, the processing roll is made of a non-metal material, and the given adjustment value is determined based on a combination of respective properties of the corrugated medium and the linerboard or based on a property of the corrugated medium, and wherein the control section is configured to execute the second control processing in such a manner as to, on the basis of a reference position defined as the position of the restriction member at the time when the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls form the corrugated medium becomes the given value, drive the motor to allow the gap to be reduced by the given adjustment value.

In the preferred embodiment having the above feature, the processing roll is made of a non-metal material, and the given adjustment value is determined based on combination of respective properties of the corrugated medium and the linerboard or based on a property of the corrugated medium. The control section executes the second control processing in such a manner as to, on the basis of a reference position defined as the position of the restriction member at the time when the magnitude of the vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls becomes the given value, drive the motor to allow the gap to be reduced by the given adjustment value. Thus, through the first control processing, the gap between the processing roll and the specific corrugating roll is set to the reference value free from influence of the vibration of the processing roll once, and then, through the second control processing, the gap is set to a final value by reducing the reference value by the given adjustment value, so that it becomes possible to apply a stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium.

In this preferred embodiment, the property of the corrugated medium or the linerboard may be a type of paperboard, such as a raw material, a basis weight and a thickness of a paperboard. The given adjustment value may be set in correlated relation with a combination of respective properties of the corrugated medium and the linerboard, or in correlated relation with a property of the corrugated medium. For example, in the case where basis weight is used as the property, the given adjustment value may be preliminarily set at a larger value along with an increase in basis weight. Further, the given adjustment value may be preliminarily stored in a storage device in correlated relation with a property of a paperboard, or may be calculated based on a value of a property of a paperboard, such as basis weight.

In a specific preferred embodiment of the first aspect of the present invention, the control section is configured to execute a processing comprising the first and second control processings, plural times, during a time period where a single-faced corrugated paperboard is produced according to one order.

In the preferred embodiment having the above feature, the control section executes a processing comprising the first and second control processings, plural times, during a time period where a single-faced corrugated paperboard is produced according to one order. Thus, even in a situation where a surrounding environment of the single facer changes during implementation of one order, it becomes possible to apply a stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium.

In this preferred embodiment, a number of times of the execution of the processing comprising the first and second control processings is determined depending on the surrounding environment of the single facer, such as an ambient temperature around the single facer at a start of an order. For example, in a situation where the surrounding environment at a start of an order is close to that in a steady operation of the single facer, the number of times of the execution of the processing comprising the first and second control processings is reduced.

In a specific preferred embodiment of the first aspect of the present invention, the control section is configured to repeatedly execute the processing comprising the first and second control processings, in such a manner that an interval of execution of the processing comprising the first and second control processings becomes longer in an intermediate stage of implementation of an order, as compared to a starting stage of the implementation of the order.

In the preferred embodiment having the above feature, the control section repeatedly executes the processing comprising the first and second control processings, in such a manner that an interval of execution of the processing comprising the first and second control processings becomes longer in an intermediate stage of implementation of an order, as compared to a starting stage of the implementation of the order. The surrounding environment of the single facer gradually becomes stable after a start of the order. Thus, the interval of execution of the processing comprising the first and second control processings is extended in the intermediate stage of the implementation of the order where the surrounding environment becomes stable. This makes it possible to efficiently execute the control processings.

In this preferred embodiment, the interval of execution of the processing comprising the first and second control processings may be preliminarily stored in a storage device, or may be calculated according to a rising rate of an ambient temperature around the single facer.

In a specific preferred embodiment of the first aspect of the present invention, the single facer further comprises a detection device configured to detect vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls, wherein the control section is configured to execute the first control processing in such a manner as to drive the motor until a magnitude of vibration detected by the detection device is reduced to a given value.

In the preferred embodiment having the above feature, the detection device detects vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls. The control section executes the first control processing according to a magnitude of vibration detected by the detection device. Thus, the restriction member is displaced by the motor, according to the magnitude of the vibration actually detected by the detection device, so that it becomes possible to apply a more stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium.

In this preferred embodiment, the detection device may have any configuration, as long as the configuration is capable of detecting the vibration occurring in the processing roll. For example, the detection device may be configured to directly detect vibration of the processing roll, or may be configured to indirectly detect vibration of the processing roll, e.g., detect vibration of a member coupled to the processing roll. Further, the detection device may be configured to detect a primary physical vibration of the processing roll or a member coupled to the processing roll, or may be detect a secondary physical vibration generated along with the primary physical vibration.

In a specific preferred embodiment of the first aspect of the present invention, the detection device is configured to detect a rotational change amount of a rotary shaft of the motor, as the vibration occurring in the processing roll, and the control section is configured to execute the first control processing in such a manner as to drive the motor until the rotational change amount of the rotary shaft of the motor is reduced to a given rotational change amount.

In the preferred embodiment having the above feature, the detection device detects a rotational change amount of a rotary shaft of the motor, as the vibration occurring in the processing roll. The control section executes the first control processing in such a manner as to drive the motor until the rotational change amount of the rotary shaft of the motor is reduced to a given rotational change amount. Thus, the detection device can detect the rotational change amount of the rotary shaft of the motor, as the vibration occurring in the processing roll, so that it is not necessary to provide a special detection device in the vicinity of the processing roll.

In this preferred embodiment, due to the vibration of the processing roll, the restriction member and the movable part of the supporting mechanism are repeatedly and alternately placed in a contact state and a separate state. When the restriction member and the movable part of the supporting mechanism are in the separate state during a time period where a drive current is continuously supplied to the motor, the rotary shaft of the motor is rotated. Then, when the restriction member comes into contact with the movable part of the supporting mechanism, the rotation of the rotary shaft of the motor is stepped. The rotational change amount is an amount of rotation in a time period from a start of the rotation of the rotary shaft of the motor through until the rotation of the rotary shaft of the motor is stopped.

In a specific preferred embodiment of the first aspect of the present invention, the detection device is configured to detect a rotation torque of the motor, as the vibration occurring in the processing roll, and the control section is configured to execute the first control processing in such a manner as to drive the motor until a state in which the rotation torque of the motor is increased to a given torque continues for a given time.

In the preferred embodiment having the above feature, the detection device detects a rotation torque of the motor, as the vibration occurring in the processing roll. The control section executes the first control processing in such a manner as to drive the motor until a state in which the rotation torque of the motor is increased to a given torque continues for a given time. Thus, the detection device can detect the rotation torque of the motor as the vibration occurring in the processing roll, so that it is not necessary to provide a special detection device in the vicinity of the processing roll.

In this preferred embodiment, the given torque is a torque with which the motor is driven to displace the restriction member by a force less than the force by which the pressing actuator section can press the processing roll against the specific corrugating roll, and the motor is driven until the magnitude of the vibration occurring in the processing roll is reduced to the given value. The given torque is set through experiment. The given time is longer than a period of the vibration occurring in the processing roll. The given time is set through experiment. The detection device may be configured to detect a value of current supplied to the motor, as the rotation torque of the motor, or may be configured to detect a value of torsion occurring in the rotary shaft of the motor, as the rotation torque of the motor.

In a specific preferred embodiment of the first aspect of the present invention, the processing roll is a press roll made of a non-metal material having elasticity greater than that of the specific corrugating roll.

In the preferred embodiment having the above feature, the processing roll is a press roll made of a non-metal material having elasticity greater than that of the specific corrugating roll. Thus, the press roll is elastically deformed when it is pressed against the specific corrugating roll, so that it becomes possible to suppress the formation of a press mark in a single-faced corrugated paperboard.

In a specific preferred embodiment of the first aspect of the present invention, the restricting mechanism further comprises: an externally-threaded shaft configured to be rotated by the motor; and a movable member formed to have an inclined surface and configured to be moved along the externally-threaded shaft while being threadingly engaged with the externally-threaded shaft, wherein the restriction member is formed to have an inclined surface being in sliding contact with the inclined surface of the movable member, and configured to be moved in a direction perpendicular to the externally-threaded shaft, in such a manner as to come into contact with the movable part of the supporting mechanism.

In the preferred embodiment having the above feature, the externally-threaded shaft is rotated by the motor, and the movable member threadingly engaged with the externally-threaded shaft is moved along the externally-threaded shaft. In the state in which the inclined surface of the restriction member is in sliding contact with the inclined surface of the movable member, the restriction member is moved in the direction perpendicular to the externally-threaded shaft, in such a manner as to come into contact with the movable part of the supporting mechanism. Thus, once the restriction member is positioned, a restriction position of the restriction member can be maintained without supplying a drive current to the motor.

In a specific preferred embodiment of the first aspect of the present invention, the supporting mechanism comprises a swingable member attached to a frame in such a manner as to be swingingly movable about a given swing axis, while supporting the processing roll, wherein the pressing actuator section is coupled to the swingable member to press the processing roll against the specific corrugating roll, and the restriction member is disposed in contactable relation to a part of the swingable member, at a position farther away from the given swing axis than a position where the processing roll is supported by the swingable member.

In the preferred embodiment having the above feature, the swingable member is attached to a frame in such a manner as to be swingingly movable about a given swing axis, while supporting the processing roll. The pressing actuator section is coupled to the swingable member to push the swingable member the processing. The restriction member can come into contact with a part of the swingable member, at a position farther away from the given swing axis than a position where the processing roll is supported by the swingable member. Thus, as compared to a configuration in which the restriction member comes into contact with a part of the swingable member, at a position closer to the given swing axis than the position where the processing roll is supported by the swingable member, it becomes possible to finely adjust the gap between the processing roll and the specific corrugating roll, when the restriction member is moved by the same distance.

In this preferred embodiment, the part of the swingable member is not limited to a portion of the swingable member, but may include a member supported by the swingable member, as long as the supported member can be swingably moved integrally with the swingable member.

Second Aspect of the Present Invention and Preferred Embodiments Thereof

In order to achieve the above object, according to the second aspect of the present invention, there is provided a single facer for producing a single-faced corrugated paperboard by forming a corrugated medium and gluing a linerboard onto the corrugated medium. The single facer comprises: a pair of corrugating rolls configured to form the corrugated medium; a processing roll configured to be brought into contact with a specific one of the corrugating rolls through the corrugated medium and the linerboard or through the corrugated medium so as to perform a given processing; first and second supporting mechanisms each supporting a respective one of opposite ends of a rotary shaft of the processing roll in such a manner as to allow a gap between the specific corrugating roll and the processing roll to be changed, wherein at least a part of each of the first and second supporting mechanisms is configured to be movable to cause a change in the gap; a pressing actuator section configured to press the processing roll against the specific corrugating roll through the corrugated medium and the linerboard or through the corrugated medium; first and second restricting mechanisms each provided for a respective one of the first and second supporting mechanisms, wherein each of the first and second restricting mechanisms comprises a restriction member disposed in contactable relation to the movable part of a respective one of the first and second supporting mechanisms, wherein the restricting mechanism is configured to allow the restriction member to be displaced with respect to the movable part of the supporting mechanism; first and second motors each provided for a respective one of the first and second restricting mechanisms and configured to be driven so as to displace a corresponding one of the restriction members; and a control section for controlling the drive of the first and second motors, wherein the control section is configured to execute a first control processing of driving the first and second motors until a magnitude of vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls is reduced to a given value.

In the second aspect of the present invention, each of the first and second restricting mechanisms is provided for a respective one of the first and second supporting mechanisms, and each of the first and second restricting mechanisms comprises a restriction member disposed in contactable relation to the movable part of a respective one of the first and second supporting mechanisms. The restricting mechanism is configured to allow the restriction member to be displaced with respect to the movable part of the supporting mechanism. Each of the first and second motors is provided for a respective one of the first and second restricting mechanisms and configured to be driven so as to displace a corresponding one of the restriction members. The control section executes a first control processing of driving the first and second motors until a magnitude of vibration occurring in the processing roll during the formation of the corrugated medium through the corrugating rolls is reduced to a given value. Thus, through the first control processing, the gap between the processing roll and the specific corrugating roll is set to a reference value free from influence of the vibration of the processing roll, so that it becomes possible to apply a stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium, by the entire region of the processing roll in its axial direction.

The second aspect of the present invention can be variously embodied as with the first aspect of the present invention. The single facer according to the second aspect of the present invention may comprise a detection device configured to detect the vibration of the processing roll. In this case, the detection device may be configured to detect the vibration of the processing roll at one point of the processing roll, or may be configured to detect the vibration of the processing roll at two point of the processing roll spaced apart from each other in the axial direction.

In a specific preferred embodiment of the second aspect of the present invention, the single facer further comprises first and second detection devices each configured to detect vibration occurring in a respective one of the opposite ends of the rotary shaft of the processing roll during the formation of the corrugated medium through the corrugating rolls, wherein the control section is configured to execute the first control processing in such a manner as to drive each of the first and second motors according to a respective one of vibration magnitudes detected by the first and second detection devices.

In the preferred embodiment having the above feature, each of the first and second detection devices detects the vibration occurring in a respective one of the opposite ends of the rotary shaft of the processing roll. The control section executes the first control processing in such a manner as to drive each of the first and second motors according to a respective one of vibration magnitudes detected by the first and second detection devices. Thus, the first control processing for the motor is executed according to vibrations actually detected by the first and second detection devices, so that it becomes possible to apply a more stable nip pressure free from influence of the vibration of the processing roll, to the corrugated medium and the linerboard or to the corrugated medium, by the entire region of the processing roll in the axial direction.

In this preferred embodiment, the control section may execute a control processing for controlling the drive of the motors, in various manners. For example, the control section may be configured to execute the first and second control processings for controlling the drive of the first motor, and the first and second control processings for controlling the drive of the second motor, in a parallel way in terms of the first and second motors, or may be configured to execute the first control processing for controlling the drive of the first and second motors and then execute the second control processing for controlling the drive of the first and second motors, in a parallel way in terms of the first and second motors.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a right side view of a single facer according to a first embodiment of the present invention.

FIG. **2** is a front view of the single facer according to the first embodiment.

FIG. **3** is an enlarged right side view illustrating a glue-roll gap adjusting mechanism for adjusting a gap between a glue roll and an upper corrugating roll in the single facer according to the first embodiment.

FIG. **4** is an enlarged right side view illustrating a press-roll gap adjusting mechanism for adjusting a gap between a press roll and the upper corrugating roll in the single facer according to the first embodiment.

FIG. **5** is a block diagram illustrating an electrical configuration of the single facer according to the first embodiment.

FIG. **6** is an explanatory diagram enlargedly illustrating a contact state between an outer peripheral surface of the press roll and ridges of a fluted portion of the upper corrugating roll.

FIG. 7 is an explanatory diagram illustrating a relationship between an internal temperature of the single facer, and a time point of a timing instruction to be generated by a lower-level management device in the single facer according to the first embodiment.

FIG. 8 is an explanatory diagram illustrating a relationship between a rotational speed of a servomotor and an elapsed time, in the single facer according to the first embodiment.

FIG. 9 is a block diagram illustrating an electrical configuration of a single facer according to a second embodiment of the present invention.

FIG. 10 is an explanatory diagram illustrating a relationship between a rotational speed of a servomotor and an elapsed time, in the single facer according to the second embodiment.

FIG. 11 is a block diagram illustrating an electrical configuration of a single facer according to a third embodiment of the present invention.

FIG. 12 is an explanatory diagram illustrating a stored content of a press-roll gap adjustment table, in the single facer according to the third embodiment.

FIG. 13 is an explanatory diagram illustrating a relationship between a rotation torque of a servomotor and an elapsed time, in the single facer according to the third embodiment.

DESCRIPTION OF EMBODIMENTS

First Embodiment

With reference to FIGS. **1** to **8**, a single facer according to a first embodiment of the present invention will be described. In the figures, an up-down direction, a right-left direction and a front-rear direction are defined according to respective directions indicated by the arrowed lines.

<General Configuration>

FIG. **1** illustrate a general configuration of a single facer **1** according to the first embodiment. The single facer **1** is designed to produce a single-faced corrugated paperboard **12** by forming a medium **10** into a corrugated configuration and gluing a linerboard **11** onto the corrugated medium **10**. A configuration of the single facer **1** has heretofore been known as disclosed, for example, in JP 2000-102996A. Thus, in particular, a configuration pertaining to a gap adjusting mechanism will be described in detail. The single facer **1** comprises a base **20**, and right and left stationary frames **21**, **22** each standing upwardly from the base **20**. The stationary frames **21**, **22** rotatably support an upper corrugating roll **23** and a lower corrugating roll **24**. Each of the corrugating rolls **23**, **24** has a corrugated-shaped fluted portion formed on an outer peripheral surface thereof. The corrugating rolls **23**, **24** are arranged to allow the corrugated-shaped fluted portions of them to be meshed with each other to thereby form the medium **10** into a corrugated configuration. Each of the corrugating rolls **23**, **24** is configured to be internally supplied with stream. Each of the corrugating rolls **23**, **24** is made of a metal material such as chromium molybdenum steel. A temperature sensor DTM is disposed in adjacent relation to the corrugating rolls **23**, **24**, and configured to detect an internal temperature of the single facer **1**.

The single facer **1** is equipped with a glue application apparatus **25**. The glue application apparatus **25** comprises a movable frame **26** movable on the base **20** in a front-rear direction. The movable frame **26** has a right support plate portion **27**, a left support plate portion **28**, and a beam member **29** disposed to extend between the support plate portions **27**, **28**. Each of the support plate portions **27**, **28** is disposed to extend perpendicularly with respect to the base **20**, and provided with a roller rollingly movable on the base **20**. The glue application apparatus **25** further comprises a glue roll **30** and a doctor roll **31**. The glue roll **30** is partially immersed in a glue pan reserving glue therein, and configured to apply glue onto flute tip regions of the corrugated medium **10** formed by the corrugating rolls **23**, **24**. The doctor roll **31** is configured to scrapingly uniform a thickness of glue adhering on an outer peripheral surface of the glue roll **30**. Each of the glue roll **30** and the doctor roll **31** is rotatably supported by the support plate portions **27**, **28**. Generally, the glue roll **30** is made of a metal material such as carbon steel, and formed in a pipe shape.

A right glue-application hydraulic cylinder **32** is attached to a left surface of the right stationary frame **21**, and comprises an extendable-retractable actuating rod **32**A. The actuating rod **32**A has a front end coupled to a right surface of the right support plate portion **27**. A left glue-application hydraulic cylinder **33** is attached to a right surface of the left stationary frame **22**, and comprises an extendable-retractable actuating rod. The actuating rod of the hydraulic cylinder **33** has a front end coupled to a left surface of the left support plate portion **28**. The glue-application hydraulic cylinders **33** are operable to pull the movable frame **26** rearwardly to cause the glue roll **30** to be pressed against the upper corrugating roll **23** through the corrugated medium **10**.

A right swingable frame **40** is swingingly movably attached to the right stationary frame **21** via a pivot shaft **41**. A left swingable frame **42** is swingingly movably attached to the left stationary frame **22** via a pivot shaft **43**. The right swingable frames **40**, **42** rotatably support a press roll **44**. The press roll **44** is configured to press the corrugated medium and the linerboard **11** toward the upper corrugating roll **23** so as to gluingly laminate the linerboard **11** to the glue-applied flue tip regions of the corrugated medium **10**. The right swingable frame **40** has a forwardly-extending arm portion **45**, and the left swingable frame **42** has a forwardly-extending arm portion **46**. Generally, the press roll **44** is made of a metal material such as carbon steel.

A right press hydraulic cylinder **47** is attached to a front end of the right stationary frame **21**, and equipped with an extendable-retractable actuating rod **47**A. The actuating rod **47**A has a lower end coupled to a front end of the arm portion **45** of the right swingable frame **40**. A left press hydraulic cylinder **48** is attached to a front end of the left stationary frame **22**, and equipped with an extendable-retractable actuating rod **48**A. The actuating rod **48**A has a lower end coupled to a front end of the arm portion **46** of the left swingable frame **42**. The press hydraulic cylinders **47**, **48** are operable to rotationally urge the respective swingable frames **40**, **42** in a counterclockwise direction about the respective pivot shafts **41**, **43** to cause the press roll **44** to be pressed against the upper corrugating roll **23** through the corrugated medium **10** and the linerboard **11**.

The medium **10** is conveyed to a position where the corrugated-shaped fluted portions of the corrugating rolls **23**, **24** are meshed with each other, via a preheater **49**. The linerboard **11** is conveyed to the press roll **44** via a preheater **50**. The corrugated medium **10** is applied with glue by the glue roll **30**, and then gluingly laminated with the linerboard **11** by the press roll **44**, to form the single-faced corrugated paperboard **12**. The single-faced corrugated paperboard **12** is conveyed while being wound around the outer peripheral surface of the upper corrugating roll **23**, and discharged toward an upper side of the single facer **1**.

The single facer **1** is further equipped with a glue-roll gap adjustment apparatus **100** for adjusting a gap between the glue roll **30** and the upper corrugating roll **23**, and a press-roll gap adjustment apparatus **200** for adjusting a gap between the press roll **44** and the upper corrugating roll **23**.

<Detailed Configuration of Glue-Roll Gap Adjustment Apparatus **100**>

The glue-roll gap adjustment apparatus **100** comprises a right glue-roll gap adjusting mechanism **110** and a left glue-roll gap adjusting mechanism **130**. The right glue-roll gap adjusting mechanism **110** is disposed between the right stationary frame **21** and the right support plate portion **27**, and the left glue-roll gap adjusting mechanism **130** is disposed between the left stationary frame **22** and the left support plate portion **28**. The right and left glue-roll gap adjusting mechanisms **110**, **130** have the same configuration. Thus, only the configuration of the right glue-roll gap adjusting mechanism **110** will be described in detail, as a representative example.

FIG. **3** is a right side view enlargedly illustrating a general configuration of the right glue-roll gap adjusting mechanism **110**. In FIG. **3**, a fixed block **111** is fixed to the right surface of the right support plate portion **27**, in such a manner as to extend rightwardly from the right surface of the right support plate portion **27**. A contact member **112** is fixed onto a rear surface of the fixed block **111** in such a manner as to protrude rearwardly from the rear surface of the fixed block **111**. On the other hand, a holder **113** is fixed onto a front end surface of the right stationary frame **21** in such a manner as to extend forwardly. A leveling block **115** is fixed to the holder **113**. The leveling block **115** primarily comprises a casing **116**, a pair of first and second wedge-shaped bodies **117**, **118**, and an externally-threaded shaft **119**. The first and second wedge-shaped bodies **117**, **118** are disposed inside the casing **116**. The first wedge-shaped body **117** is formed to have an inclined surface **117**A, and configured to be slidingly moved on a wall surface of a wall portion **116**A of the casing **116**, wherein the wall portion **116**A extends in an up-down direction. The second wedge-shaped body **118** is formed to have an inclined surface **118**A being in sliding contact with the inclined surface **117**A, and configured to be displaced in the front-rear direction while being guided by a pair of opposed wall portions **116**B, **116**C of the casing **116**, wherein each of the wall portions **116**B, **116**C extends forwardly. The externally-threaded shaft **119** is disposed to extend upwardly from the wall portion **116**B, and threadingly engaged with an internally-threaded portion formed inside the first wedge-shaped body **117**. As regards the leveling block **115**, various types of products are commercially available. For example, it is commercially supplied from NABEYA Co., Ltd., as a model number: Leveling Block A-type. Further, a fundamental configuration of the leveling block has heretofore been known as disclosed, for example, in JP 2008-087139 A.

A servomotor **120** is fixed to a support wall member **114**. The servomotor **120** has an output shaft **120**A coupled to the externally-threaded shaft **119** via a coupling member. The servomotor **120** incorporates an encoder EC 11 for detecting rotation of the output shaft **120**A.

An adjusting screw **121** is installed in a front end surface of the second wedge-shaped body **118** in such a manner as to be threadingly engaged with an internally-threaded portion formed inside the second wedge-shaped body **118**. An amount of protrusion of the adjusting screw **121** protruding forwardly from the front end surface of the second wedge-shaped body **118** can be manually adjusted by an operator. A head of the adjusting screw **121** is disposed in opposed relation to and in contactable relation to a distal end of the contact member **112**.

As with the right glue-roll gap adjusting mechanism **110**, the left glue-roll gap adjusting mechanism **130** comprises a fixed block **131**, a contact member, a holder **133**, a leveling block **135**, a servomotor **140** incorporating an encoder EC12, and an adjusting screw.

<Detailed Configuration of Press-Roll Gap Adjustment Apparatus **200**>

The press-roll gap adjustment apparatus **200** comprises aright press-roll gap adjusting mechanism **210** and a left press-roll gap adjusting mechanism **230**. The right press-roll gap adjusting mechanism **210** is disposed between the right stationary frame **21** and arm portion **45** of the right swingable frame **40**, and the left press-roll gap adjusting mechanism **230** is disposed between the left stationary frame **22** and arm portion **46** of the left swingable frame **42**. The right and left press-roll gap adjusting mechanisms **210**, **230** have the same configuration. Thus, details of the configuration will be described by taking the right press-roll gap adjusting mechanism **210** as an example.

FIG. **4** is a right side view enlargedly illustrating a general configuration of the right press-roll gap adjusting mechanism **210**. In FIG. **4**, a coupling block **211** is provided to couple the lower end of the actuating rod **47**A of the right press hydraulic cylinder **47** to the distal (front) end of the arm portion **45**. Further, a contact member **212** is fixed to a lower end of the coupling block **211** in such a manner as to protrude downwardly from the lower end of the coupling block **211**. As illustrated in FIG. **1**, a distance D1 between the contact member **212** and an axis (X) of the pivot shaft **41** is set to be greater than a distance D2 between a rotation center of the press roll **44** and the axis (X) of the pivot shaft **41**. On the other hand, a holder **213** is fixed onto the front end surface of the right stationary frame **21** in such a manner as to extend upwardly. A leveling block **215** is fixed to the holder **213**. The leveling block **215** primarily comprises a casing **216**, a pair of third and fourth wedge-shaped bodies **217**, **218**, and an externally-threaded shaft **219**. The third and fourth wedge-shaped bodies **217**, **218** are disposed inside the casing **216**. The third wedge-shaped body **217** is formed to have an inclined surface **217**A, and configured to be slidingly moved on a wall surface of a wall portion **216**A of the casing **216**, wherein the wall portion **216**A extends in the front-rear direction. The fourth wedge-shaped body **218** is formed to have an inclined surface **218**A being in sliding contact with the inclined surface **217**A, and configured to be displaced in the up-down direction while being guided by a pair of opposed wall portions **216**B, **216**C of the casing **216**, wherein each of the wall portions **216**B, **216**C extends upwardly. The externally-threaded shaft **219** is disposed to extend rearwardly from the wall portion **216**B, and threadingly engaged with an internally-threaded portion formed inside the third wedge-shaped body **217**. The leveling block **215** has the same configuration as the leveling block **115** of the right glue-roll gap adjusting mechanism **110**.

A servomotor **220** is fixed to a support wall member **214**. The servomotor **220** has an output shaft **220**A coupled to the externally-threaded shaft **219** via a coupling member. The servomotor **220** incorporates an encoder EC21 for detecting rotation of the output shaft **220**A.

An adjusting screw **121** is installed in an upper end surface of the fourth wedge-shaped body **218** in such a manner as to be threadingly engaged with an internally-threaded portion formed inside the fourth wedge-shaped body **218**. An amount of protrusion of the adjusting screw **221** protruding upwardly from the upper end surface of the fourth wedge-shaped body **218** can be manually adjusted by an operator. A head of the adjusting screw **221** is disposed in opposed relation to and in contactable relation to a distal end of the contact member **212**.

As with the right press-roll gap adjusting mechanism **210**, the left press-roll gap adjusting mechanism **230** comprises a coupling block **231**, a contact member, a holder **233**, a leveling block **235**, a servomotor **240** incorporating an encoder EC22, and an adjusting screw.

<<Electrical Configuration>>

With reference to FIG. **5**, an electrical configuration of the single facer **1** according to the first embodiment will be described below. FIG. **5** is a block diagram illustrating the electrical configuration of the single facer **1** according to the first embodiment. As illustrated in FIG. **5**, an upper-level management device **300** is provided to generally manage production of a single-faced corrugated paperboard in the single facer **1**. The upper-level management device **300** is configured to send, to a lower-level management device **310**, control instruction information about a rotational speed of a main drive motor, an amount of production of single-faced corrugated paperboards, a type of paperboard such as a thickness of a paperboard, etc., according to a production management plan regarding a large number of predetermined orders.

The lower-level management device **310** is configured to instruct various control devices to control drive sections for the hydraulic cylinders, the servomotors, the preheaters, etc., according to the control instruction information received from the upper-level management device **300**. In the second embodiment, only an electrical configuration pertaining to operations of the glue-roll gap adjustment apparatus **100** and the press-roll gap adjustment apparatus **200** will be described.

A program memory **320** fixedly stores therein programs such as a main control routine of the single facer **1**, an adjustment instruction routine for determining a timing of generating an instruction for a start of gap adjustment control, and fixedly stores therein various preset values. A working memory **330** is configured to temporarily store therein a result of processing by the lower-level management device **310**. An operation panel **340** is connected to the lower-level management device **310**. The operation panel **340** has an order start button **341**. The order start button **341** is a button to be manually operated by an operator in order to start to implement one order. The temperature sensor DTM is connected to the lower-level management device **310**, and configured to send a temperature detection signal indicative of an internal temperature of the single facer **1** to the lower-level management device **310**.

For example, as the preset values, the program memory **320** stores therein a hydraulic pressure value for the glue roll **30**, a hydraulic pressure value for the press roll **44**, a given glue-roll vibration threshold value, a given press-roll vibration threshold value, a glue-roll gap adjustment value, a press-roll gap adjustment value, first and second torque values for adjusting a glue-roll gap, and first and second torque values for adjusting a press-roll gap, in correlated relation with a type of paperboard, such as a raw material and a thickness of a paperboard. The lower-level management device **310** is configured to, among the control instruction information sent from the upper-level management device **300** according to each order, read various preset values correlated with a type of paperboard from the program memory **320**, and send the preset values to each control device. In the first embodiment, the glue-roll gap adjustment value for the glue roll **30** is stored in correlated relation with a thickness of the corrugated medium **10**, and the press-roll gap adjustment value for the press roll **44** is stored in correlated relation with a combination of respective thickness of the corrugated medium **10** and the linerboard **11**. Generally, each of the glue-roll gap adjustment value and the press-roll gap adjustment value is set to a larger value along with an increase in thickness of a paperboard for the corrugated medium, etc.

A glue-application cylinder control device **350** is connected to the lower-level management device **310**, and configured to control operation of the right and left right glue-application hydraulic cylinders **32**, **33**, according the control instruction information including a hydraulic pressure value, received from the lower-level management device **310**. A level of hydraulic pressure to be generated by each of the glue-application hydraulic cylinders **32**, **33** is instructed by the hydraulic pressure value for the glue roll **30**, received from the lower-level management device **310**. A press cylinder control device **351** is connected to the lower-level management device **310**, and configured to control operation of the right press hydraulic cylinders **47**, **48**, according the control instruction information including a hydraulic pressure value, received from the lower-level management device **310**. A level of hydraulic pressure to be generated by each of the press hydraulic cylinders **47**, **48** is instructed by the hydraulic pressure value for the press roll **44**, received from the lower-level management device **310**.

A glue-roll gap adjusting motor control device **352** is connected to the lower-level management device **310**, and configured to control a rotation direction and a drive current of each of the servomotors **120**, **140**, according the control instruction information from the lower-level management device **310**. Specifically, the glue-roll gap adjusting motor control device **352** is configured to control the rotation direction and the drive current of the servomotor **120**, based on the control instruction information from the lower-level management device **310** and detection pulses from the encoder EC11. The gap between the glue roll **30** and the upper corrugating roll **23** is instructed by the glue-roll gap adjustment value from the lower-level management device **310**. Further, the glue-roll gap adjusting motor control device **352** is configured to control a rotation direction and a drive current of the servomotor **140**, based on the control instruction information from the lower-level management device **310** and the detection pulses from the encoder EC12. The glue-roll gap adjusting motor control device **352** fixedly stores in an internal memory **352**A an adjustment control routine to perform glue-roll gap adjustment control, wherein it is configured to execute the adjustment control routine according to a timing instruction from the lower-level management device **310**. The glue-roll gap adjusting motor control device **352** is composed of a computer comprising the internal memory **352**A.

A press-roll gap adjusting motor control device **353** is connected to the lower-level management device **310**, and configured to control a rotation direction and a drive current of each of the servomotors **220**, **240**, according the control instruction information from the lower-level management device **310**. Specifically, the press-roll gap adjusting motor control device **353** is configured to control the rotation direction and the drive current of the servomotor **220**, based on the control instruction information from the lower-level management device **310** and the detection pulses from the encoder EC21. The gap between the press roll **44** and the upper corrugating roll **23** is instructed by the press-roll gap adjustment value from the lower-level management device **310**. Further, the press-roll gap adjusting motor control device **353** is configured to control a rotation direction and a drive current of the servomotor **240**, based on the control instruction information from the lower-level management device **310** and the detection pulses from the encoder EC22. The press-roll gap adjusting motor control device **353** fixedly stores in an internal memory **353**A an adjustment control routine to perform press-roll gap adjustment control, wherein it is configured to execute the adjustment control routine according to a timing instruction from the lower-level management device **310**. The press-roll gap adjusting motor control device **353** is composed of a computer comprising the internal memory **353**A.

<<Operation and Functions of Single Facer According to First Embodiment>>

An operation and functions of the single facer **1** according to the first embodiment will be described below. In the single facer **1**, during the formation of the corrugated medium **10** through the corrugating rolls **23**, **24**, each of the glue roll **30** and the press roll **44** periodically comes into contact with one or more ridges of the fluted portion of the upper corrugating roll **23**, through the corrugated medium **30** or through the corrugated medium **30** and the linerboard **11**, so that the periodic contacts cause vibration in each of the press roll and the glue roll. Further, in the single facer **1**, the formation of the corrugated medium **10** through the corrugating rolls **23**, **24**, steam is fed into at least the corrugating rolls **23**, **24** to heat the corrugating rolls **23**, **24**, and thereby an inside of the single facer **1** has a high temperature, which causes thermal strain in components of the single facer **1**. Therefore, it is necessary to accurately adjust the gap between the glue roll **30** and the upper corrugating roll **23** and the gap between the press roll **44** and the upper corrugating roll **23**, while maximally avoiding an influence of the thermal strain on the components.

<Vibrations Occurring in Glue Roll **30** and Press Roll **44**>

With reference to FIG. **6**, vibrations occurring in the glue roll **30** and the press roll **44** will be described. A mechanism for causing vibration to occur in the glue roll **30** and a mechanism for causing vibration to occur in the press roll **44** are the same in that both of the vibrations occur due to the periodic contacts with the upper corrugating roll **23**. FIG. **6** enlargedly illustrates a contact state between ridges of the fluted portion of the upper corrugating roll **23** and the press roll **44**.

In FIG. **6**, an outer peripheral surface **44**A of the press roll **44** is in contact with two adjacent ridges **23**A, **23**B of the fluted portion of the upper corrugating roll **23**. A circle CR connecting tops of all ridges of the fluted portion of the upper corrugating roll **23** is indicated by the two-dot chain line in FIG. **6**. In a state in which the outer peripheral surface **44**A of the press roll **44** is in contact with the ridges **23**A, **23**B of the fluted portion of the upper corrugating roll **23**, the outer peripheral surface **44**A penetrates across the circle CR toward a center of the upper corrugating roll **23**. A penetration amount AS of the outer peripheral surface **44**A indicated in FIG. **6** is determined depending on a diameter of the press roll **44**. When the upper corrugating roll **23** is rotated, and the outer peripheral surface **44**A comes into contact with a ridge **23**C indicated by the two-dot chain line in FIG. **6**, the outer peripheral surface **44**A is moved outwardly and located on the circle CR. As a result, due to the periodic contacts of the outer peripheral surface **44**A with one or more ridges of the fluted portion of the upper corrugating roll **23**, the press roll **44** vibrates at an amplitude equivalent to the penetration amount AS.

As with the press roll **44**, the outer peripheral surface of the glue roll **30** periodically comes into contact with one or more ridges of the fluted portion of the upper corrugating roll **23**, and therefore vibrates. An amplitude of the vibration of the glue roll **30** is determined depending on a diameter of the glue roll **30**.

<Timing Instruction according to Adjustment Instruction Routine>

With reference to FIG. **7**, processing of the adjustment instruction routine for determining a timing of generating an instruction for a start of the gap adjustment control will be described. FIG. **7** illustrates a relationship between an internal temperature of the single facer **1** and a time point of generation of the timing instruction. When an operator manually operates the order start button **341**, the lower-level management device **310** reads the adjustment instruction routine from the program memory **320** and executes the adjustment instruction routine. The execution of the adjustment instruction routine will be terminated when implementation of an order is completed.

According to a temperature detection signal from the temperature sensor DTM, the lower-level management device **310** determines whether or not an internal temperature change amount in the single facer **1** is equal to or greater than a given temperature change amount. When it is determined that the internal temperature change amount is equal to or greater than the given temperature change amount, the lower-level management device **310** instructs each of the glue-roll gap adjusting motor control device **352** and the press-roll gap adjusting motor control device **353** to start the gap adjustment control. In FIG. **7**, in a time period from order start time point T0 to time point T6, the internal temperature of the single facer **1** is rapidly increased, and therefore the lower-level management device **310** generates the timing instruction for the start of the gap adjustment control, at respective time points T1 to T6, at relatively short time intervals.

According to the temperature detection signal from the temperature sensor DTM, the lower-level management device **310** also determines whether or not the internal temperature of the single facer **1** has been increased to a reference temperature TRF set for production of the single-faced corrugated paperboard **12**. When it is determined that the internal temperature of the single facer **1** has been increased to the reference temperature TRF, the lower-level management device **310** generates the timing instruction at given time intervals PTL. The given time interval PTL is longer than each of a plurality of different time intervals at which the timing instruction is generated in the time period from the time point T0 to the time point T8. In the first embodiment, the given temperature change amount and the given time interval PTL are fixedly stored in the program memory **320** as the various preset values.

<Gap Adjustment Control according to Adjustment Control Routine>

With reference to FIG. **8**, the gap adjustment control according to the adjustment control routine will be described. The gap adjustment controls to be performed by the glue-roll gap adjusting motor control device **352** and the press-roll gap adjusting motor control device **353** are approximate the same. Thus, only the gap adjustment control to be performed by the press-roll gap adjusting motor control device **353** will be described below, as a representative example. FIG. **8** illustrates a relationship between a rotational speed of the servomotor **220** and an elapsed time (second).

Upon operation of the order start button **341** by an operator, the lower-level management device **310** reads the hydraulic pressure value for the glue roll **30** and the hydraulic pressure value for the press roll **44**, from the program memory **320**, and sends the read hydraulic pressure values as the control instruction information to the glue-application cylinder control device **350** and the press cylinder control device **351**, respectively. Thus, the glue-application cylinder control device **350** controls a hydraulic pressure of each of the hydraulic cylinders **32**, **33** according to the hydraulic pressure value for the glue roll **30**. The press cylinder control device **351** controls a hydraulic pressure of each of the hydraulic cylinders **47**, **48** according to the hydraulic pressure value for the press roll **44**. During a time period where a specific order is implemented, the hydraulic pressure of each of the hydraulic cylinders **32**, **33** is controlled to be maintained at a constant value, and the hydraulic pressure of each of the hydraulic cylinders **47**, **48** is also controlled to be maintained at a constant value.

Every time the timing instruction is received from the lower-level management device **310**, the press-roll gap adjusting motor control device **353** performs the press-roll gap adjustment control according to the adjustment control routine. When receiving the timing instruction from the lower-level management device **310**, the press-roll gap adjusting motor control device **353** also receives, from the lower-level management device **310**, control instruction information about the given press-roll vibration threshold value, the press-roll gap adjustment value, the first and second torque values for adjusting a press-roll gap, etc.

First of all, according to the adjustment control routine, the press-roll gap adjusting motor control device **353** operates to rotationally drive the servomotor **220** with a drive current corresponding to the first torque value, until the third wedge-shaped body **217** of the leveling block **215** illustrated in FIG. **4** comes into contact with the wall portion **216**C of the casing **216**. When the third wedge-shaped body **217** comes into contact with the wall portion **216**C of the casing **216**, generation of the detection pulses from the encoder EC21 is stopped. Then, the press-roll gap adjusting motor control device **353** recognizes the contact of the third wedge-shaped body **217** with the wall portion **216**C, based on the stop of the generation of the detection pulses, and operates to stop of a supply of the drive current to the servomotor **220**. In the state in which the third wedge-shaped body **217** is in contact with the wall portion **216**C, the head of the adjusting screw **221** is spaced apart from the contact member **212** of the coupling block **211**. In the state in which the head of the adjusting screw **221** is spaced apart from the contact member **212**, the hydraulic pressure of the hydraulic cylinder **47** fully acts to press the press roll **44** against the corrugating roll **23**. The press-roll gap adjusting motor control device **353** also controls drive of the servomotor **240** in the same manner as that for the servomotor **220**, to cause a wedge-shaped body of the leveling block **235** to come into contact with a wall portion of a casing. Thus, the hydraulic pressure of the hydraulic cylinder **48** fully acts to press the press roll **44** against the corrugating roll **23**.

Then, according to the adjustment control routine, the press-roll gap adjusting motor control device **353** operates to rotationally drive the servomotor **220** with the drive current corresponding to the first torque value, until the head of the adjusting screw **221** of the fourth wedge-shaped body **218** of the leveling block **215** illustrated in FIG. **4** comes into contact with the contact member **212** of the coupling block **211**. During a time period where the head of the adjusting screw **221** is moved toward the contact member **212**, the press roll **44** vibrates due to periodic contact with the ridges of the fluted portion of the upper corrugating roll **23**. The vibration of the press roll **44** is transmitted to the contact member **212** of the coupling block **211** via the swingable frame **40** and the arm portion **45**. That is, the adjusting screw **221** is moved toward the contact member **212** being vibrating. The first torque value is a value of rotation torque of the servomotor **220** set such that it fails to overcome a force by which the contact member **212** can press the adjusting screw **221** according to the hydraulic pressure of the press hydraulic cylinder **47**, and therefore rotation of the servomotor **220** is stopped when the adjusting screw **221** comes into contact with the contact member **212**.

In FIG. **8**, time point TM0 indicates a time point when the drive of the servomotor **220** is started to move the head of the adjusting screw **221** toward the contact member **212**. After the time point TM0, the rotational speed of the servomotor **220** is increased. At time point TM1 when the head of the adjusting screw **221** starts to come into contact with the contact member **212** being vibrating, the increase of the rotational speed of the servomotor **220** is stopped. When a pressing force of the contact member **212** applied to the head of the adjusting screw **221** becomes larger, the rotational speed of the servomotor **220** is reduced after time point TM2. Subsequently, at time point TM3, the rotation of the servomotor **220** is stopped. The press-roll gap adjusting motor control device **353** recognizes the rotational speed of the servomotor **220**, based on a frequency of the detection pulses from the encoder EC21, and recognizes stop of the rotation of the servomotor **220**, based on stop of the generation of the detection pulses. Even after the rotation of the servomotor **220** is stopped at the time point TM3, the press-roll gap adjusting motor control device **353** operates to continue to supply the drive current corresponding to the first torque value, to the servomotor **220**.

At the time point TM3 when the rotation of the servomotor **220** is stopped, the head of the adjusting screw **221** is moved to a position where it periodically comes into contact with the contact member **212**, and stopped at the position. Even when the head of the adjusting screw **221** receives a large pressing force from the contact member **212**, a position of the head of the adjusting screw **221** at a time when it is stopped is held by a function of the leveling block **215**, so that the servomotor **220** is kept from being reversely rotated.

When the contact member **212** being vibrating is temporarily moved away from the head of the adjusting screw **221**, the servomotor **220** starts to rotate again after time point TM4. After the time point TM4, the rotational speed of the servomotor **220** is increased. At time point TM5 when the head of the adjusting screw **221** starts to come into contact with the contact member **212** being vibrating, the increase of the rotational speed of the servomotor **220** is stopped. When the pressing force of the contact member **212** applied to the head of the adjusting screw **221** becomes larger again, the rotational speed of the servomotor **220** is reduced after time point TM6. Subsequently, at time point TM7, the rotation of the servomotor **220** is stopped. In a time period from the time point TM0 to the time point TM3, the head of the adjusting screw **221** is moved toward the contact member **212**, so that a downward movement (in FIG. **4**) of the contact member **212** is restrained by the adjusting screw **221**, and therefore the vibration amplitude of the contact member **212** is restricted. Thus, the rotational speed of the servomotor **220** at the time point TM5 becomes less than the rotational speed of the servomotor **220** at the time point TM1.

As the adjusting screw **221** is moved upwardly (in FIG. **4**) according to the rotation of the servomotor **220**, the vibration amplitude of the contact member **212** is gradually restricted to a smaller value. The press-roll gap adjusting motor control device **353** determines whether or not a maximum rotational speed in a time period where the servomotor **220** is rotated is reduced to a given rotational speed. For example, it is determined whether or not a maximum rotational speed reaching at the time point TM5 in a time period from the time point TM4 to the time point TM7 is reduced to a given rotational speed. The given rotational speed is determined based on the given press-roll vibration threshold value sent from the lower-level management device **310** as the control instruction information. The press-roll vibration threshold value represents a given value which is a magnitude of vibration in a state in which the vibration of the press roll **44** is approximately suppressed. The given rotational speed is a maximum rotational speed of the servomotor **220** when the servomotor **220** is driven with the drive current corresponding to the first torque value in the situation where the magnitude of vibration of the press roll **44** is equal to the press-roll vibration threshold value, and measured preliminarily and experimentally. The given rotational speed is stored in the internal memory of the press-roll gap adjusting motor control device **353** in the form of a table, in correlated relation with the type of servomotor and the press-roll vibration threshold value.

For example, when a maximum rotational speed of the servomotor **220** in a time period from time point TM24 to time point TM27 is reduced to the given rotational speed, the press-roll gap adjusting motor control device **353** stores, in an internal temporary memory thereof, a rotation amount by which the servomotor **220** is rotated in a time period from the time point TM0 to the time point TM27, as a reference rotation amount, in correlated relation with an internal temperature of the single facer **1** at the time point TM0. A position of the head of the adjusting screw **221** at the time point TM27 is set as a reference position for adjusting a gap between a right end portion of the press roll **44** illustrated in FIG. **2** and the upper corrugating roll **23**. When the reference rotation amount stored this time is different from a reference rotation amount stored last time, by a given amount or more, there is a possibility that abnormality occurs, for example, in the contact between the contact member and the adjusting screw. Thus, in such a situation, an error message may be indicated or displayed.

After the adjusting screw **221** is set at the reference position, the press-roll gap adjusting motor control device **353** operates to rotationally drive the servomotor **220** with a drive current corresponding to the second torque value so as to allow the gap between the press roll **44** and the upper corrugating roll **23** to be increased from a reference gap between the two rolls **44**, **23** at a time when the adjusting screw **221** is located at the reference position, by the press-roll gap adjustment value. The second torque value is a value of rotation torque of the servomotor **220** set such that it overcomes the force by which the contact member **212** can press the adjusting screw **221** according to the hydraulic pressure of the press hydraulic cylinder **47**, and therefore the adjusting screw **221** can move the contact member **212**. The press-roll gap adjustment value is a value obtained by subtracting a total thickness of the corrugated medium **10** and the linerboard **11** at a time when the corrugated medium **10** and the linerboard **11** are compressed by a compression force corresponding to a pressing force applied from the contact member **212** to the adjusting screw **221** when the adjusting screw **221** is located at the reference position, from a total thickness of the corrugated medium **10** and the linerboard **11** in an uncompressed state, and set experimentally.

When rotationally driving the servomotor **220** by a rotation amount corresponding to the press-roll gap adjustment value, the press-roll gap adjusting motor control device **353** operates to stop the rotation of the servomotor **220**. In this case, the adjusting screw **221** moves the contact member **212** upwardly (in FIG. **4**) from the reference position by an amount corresponding to the press-roll gap adjustment value. Thus, the swingable frame **40** is slightly rotated about the pivot shaft **41** in a clockwise direction, and positioned, so that the right end portion of the press roll **44** is positioned with respect to the upper corrugating roll **23**, with a gap increased from the reference position by the press-roll gap adjustment value, therebetween.

The press-roll gap adjusting motor control device **353** also performs control of the servomotor **240** in a parallel way, in the same manner as that for the servomotor **220**. Thus, a head of the adjusting screw of the leveling block **235** is set at a reference position for adjusting a gap between a left end portion (in FIG. **2**) of the press roll **44** and the upper corrugating roll **23**. Subsequently, the swingable frame **42** is slightly rotated about the pivot shaft **43**, and positioned, so that the left end portion of the press roll **44** is positioned with respect to the upper corrugating roll **23**, with a gap increased from the reference position by the press-roll gap adjustment value, therebetween.

As with the press-roll gap adjusting motor control device **353**, the glue-roll gap adjusting motor control device **352** receives, from the lower-level management device **310**, control instruction information about the given glue-roll vibration threshold value, the glue-roll gap adjustment value, the first and second torque values for adjusting a glue-roll gap, etc., and performs control of the servomotors **120**, **140**. Thus, each of the heads of the adjusting screws of the leveling blocks **115**, **135** are set at a reference position for adjusting a gap between a respective one of right and left end portions of the glue roll **30** illustrated in FIG. **2** and the upper corrugating roll **23**. Subsequently, the support plate portions **27**, **28** are slightly moved and then positioned, so that each of the right and left end portions of the glue roll **30** is also positioned with respect to the upper corrugating roll **23**, with a gap equivalent to the glue-roll gap adjustment value, therebetween. The glue-roll gap adjustment value is a value obtained by subtracting a thickness of the corrugated medium **10** at a time when the corrugated medium **10** is compressed by a compression force corresponding to a pressing force applied from the contact member **112** to the adjusting screw **121** when the adjusting screw **121** is located at the reference position, from a thickness of the corrugated medium **10** in an uncompressed state, and set experimentally. The glue-roll vibration threshold value represents a given value which is a magnitude of vibration in a state in which the vibration of the glue roll **30** is approximately suppressed. A given rotational speed is a maximum rotational speed of each of the servomotors **120**, **140** when the servomotor is driven with a drive current corresponding to the first torque value in the situation where the magnitude of vibration of the glue roll **30** is equal to the glue-roll vibration threshold value, and measured preliminarily and experimentally. The given rotational speed for each of the servomotors **120**, **140** is stored in the internal memory of the glue-roll gap adjusting motor control device **352** in the form of a table, in correlated relation with the type of servomotor and the glue-roll vibration threshold value.

<<Effects of Single Facer According to First Embodiment>>

In the first embodiment, the encoder EC21 for detecting the rotation of the servomotor **220** is used to detect the magnitude of the vibration occurring in the press roll **44**, so that it is not necessary to provide a special vibration detection device in the vicinity of the press roll **44**. Further, the encoder EC 11 for detecting the rotation of the servomotor **120** is used to detect the magnitude of the vibration occurring in the glue roll **30**, so that it is not necessary to provide a special vibration detection device in the vicinity of the glue roll **30**. Generally, such a special vibration detection device is likely to confront a problem of difficulty in accurately detecting the magnitude of the vibration of the processing roll (press or glue roll), because it is exposed to high temperatures and floating dust inside the single facer **1**. In contrast, the utilization of the encoder of the servomotor makes it possible to accurately detect the vibration of the processing roll.

In the first embodiment, the press roll **44** is supported by the pair of swingable frames **40**, **42** at right and left ends thereof, independently. Thus, a gap between the left end portion of the press roll **44** and the upper corrugating roll **23** is likely to become different from a gap between the right end portion of the press roll **44** and the upper corrugating roll **23**. For this reason, in the first embodiment, the gap adjustment control is configured to control the two servomotors **220**, **240** to allow the gap between the left end portion of the press roll **44** and the upper corrugating roll **23** to become equal to the gap between the right end portion of the press roll **44** and the upper corrugating roll **23**. This makes it possible to set an even gap over the entire region of the press roll **44** in its rotational axis direction. The gap adjustment control is also configured to control the two servomotors **120**, **140** to allow the gap between the left end portion of the glue roll **30** and the upper corrugating roll **23** to become equal to the gap between the right end portion of the glue roll **30** and the upper corrugating roll **23**. This makes it possible to set an even gap over the entire region of the glue roll **30** in its rotational axis direction.

In the first embodiment, the lower-level management device **310** is configured to generate the timing instruction for a start of the gap adjustment routine, when the internal temperature change amount in the single facer **1** becomes equal to the given temperature change amount, wherein, in a starting stage of implementation of an order, the timing instruction is generated at relatively short time intervals to thereby perform the gap adjustment control with relatively high frequency. Thus, even in a situation where thermal strain occurs in components of the single facer **1** due to a rapid change of the internal temperature of the single facer **1**, it becomes possible to maintain the gap between the processing roll (e.g., the press roll **44**) and the upper corrugating roll **23** at a given gap.

In the first embodiment, as illustrated in FIG. **1**, the distance D1 between the contact member **212** and the axis of the pivot shaft **41** is set to be greater than the distance D2 between the rotation center of the press roll **44** and the axis of the pivot shaft **41**. Thus, when the press roll **44** vibrates, vibration of the contact member **212** becomes greater than vibration of the rotation center of the press roll **44**, so that it becomes possible to accurately detect a change in magnitude of the vibration of the contact member **212**, in the form of a change in rotational speed of the servo motor **220**. In addition, as compared to a configuration in which the contact member **212** comes into contact with the adjusting screw **221** at a position closer to the pivot shaft **41** of the press roll **44** (swingable frame **40**), it becomes possible to finely adjust the gap between the press roll **44** and the upper corrugating roll **23**, even when the adjusting screw **221** is moved by the same distance.

Second Embodiment

With reference to the drawings, a single facer **1** according to a second embodiment of the present invention will be described. In the first embodiment, each of the control devices, for example, the press-roll gap adjusting motor control device **353**, is configured to, based on the detection pulses from the encoder EC21, determine whether or not the maximum rotational speed of the servomotor **220** is reduced to the given rotational speed. The second embodiment is different from the first embodiment in that the single facer according to the second embodiment is configured to determine whether or not the maximum rotational speed of the servomotor is reduced to a given rotational speed, based on an elapse of a given control time period after the rotation of the servomotor is first stopped, without using a detection device such as an encoder. Thus, only this difference will be described below. In the second embodiment, the same element or component as that in the first embodiment is assigned with the same reference numeral or sign, and its detailed description will be appropriately omitted.

<<Electrical Configuration>>

A mechanical configuration of the single facer **1** according to the second embodiment is the same as that in the first embodiment. Thus, only an electrical configuration of the single facer **1** according to the second embodiment will be described with reference to FIG. **9**. In particular, the second embodiment is different from the first embodiment in terms of configurations of a glue-roll gap adjusting motor control device **400** and a press-roll gap adjusting motor control device **403**. Thus, the following description will be made with a focus on the configurations of the two control devices. FIG. **9** is a block diagram illustrating the electrical configuration of the single facer **1** according to the second embodiment.

In FIG. **9**, the glue-roll gap adjusting motor control device **400** is connected to a lower-level management device **310**, and configured to control a rotation direction and a drive current of two servomotors **120**, **140**, according control instruction information from the lower-level management device **310**. Specifically, the glue-roll gap adjusting motor control device **400** is configured to receive control instruction information such as a glue-roll gap adjustment value, and first and second torque values for adjusting a glue-roll gap, from the lower-level management device **310**. The glue-roll gap adjusting motor control device **400** is configured to control the rotation direction and the drive current of each of the servomotors **120**, **140**, based on the received control instruction information, and a control time period from a control time period memory **402**. A gap between a glue roll **30** and an upper corrugating roll **23** is instructed by the glue-roll gap adjustment value from the lower-level management device **310**. The glue-roll gap adjusting motor control device **400** fixedly stores in an internal memory **400**A an adjustment control routine to perform glue-roll gap adjustment control, wherein it is configured to execute the adjustment control routine according to a timing instruction from the lower-level management device **310**. The glue-roll gap adjusting motor control device **352** is composed of a computer comprising the internal memory **400**A.

In the second embodiment, an elapsed time from a time when rotation of each of the servomotors is first stopped after the servomotor is rotationally driven with a drive current corresponding to the first torque value so as to move an adjusting screw of each leveling block toward a contact member, as described later, in a state in which the glue roll **30** is fully pressed against the upper corrugating roll **23** by hydraulic cylinders **32**, **33**, while interposing a corrugated medium **10** therebetween, to a time when a maximum rotational speed of each of the servomotors is reduced to a given rotational speed corresponding to the given glue-roll vibration threshold value in the first embodiment is measured preliminarily and experimentally. The measured elapsed time varies depending on a type of paperboard for the corrugated medium **10**, i.e., a raw material, a thickness, etc., of a paperboard for the corrugated medium **10**. Thus, the control time period memory **402** fixedly stores therein the preliminarily measured elapsed time, as a control time period, in correlated relation with the type of paperboard for the corrugated medium **10**.

The press-roll gap adjusting motor control device **403** is connected to the lower-level management device **310**, and configured to control a rotation direction and a drive current of two servomotors **220**, **240**, according control instruction information from the lower-level management device **310**. Specifically, the press-roll gap adjusting motor control device **403** is configured to receive control instruction information such as a press-roll gap adjustment value, and first and second torque values for adjusting a press-roll gap, from the lower-level management device **310**. The press-roll gap adjusting motor control device **403** is configured to control the rotation direction and the drive current of each of the servomotors **220**, **240**, based on the received control instruction information, and a control time period from a control time period memory **404**. A gap between a press roll **44** and the upper corrugating roll **23** is instructed by the press-roll gap adjustment value from the lower-level management device **310**. The glue-roll gap adjusting motor control device **403** fixedly stores in an internal memory **403**A an adjustment control routine to perform press-roll gap adjustment control, wherein it is configured to execute the adjustment control routine according to the timing instruction from the lower-level management device **310**. The press-roll gap adjusting motor control device **403** is composed of a computer comprising the internal memory **403**A.

In the second embodiment, an elapsed time from a time when rotation of each of the servomotors is first stopped after the servomotor is rotationally driven with a drive current corresponding to the first torque value so as to move an adjusting screw of a leveling block toward a contact member as described later, in a state in which the press roll **44** is fully pressed against the upper corrugating roll **23** by hydraulic cylinders **47**, **48**, while interposing the corrugated medium **10** and a linerboard **11** therebetween, to a time when a maximum rotational speed of each of the servomotors is reduced to a given rotational speed corresponding to the given press-roll vibration threshold value in the first embodiment is measured preliminarily and experimentally. The measured elapsed time varies depending on a type of paperboard for each of the corrugated medium **10** and the linerboard **11**, i.e., a raw material, a thickness, etc., of a paperboard for each of the corrugated medium **10** and the linerboard **11**. Thus, the control time period memory **404** fixedly stores therein the preliminarily measured elapsed time, as a control time period, in correlated relation with the type of paperboard for each of the corrugated medium **10** and the linerboard **11**.

<<Operation and Functions of Single Facer According to Second Embodiment>>

An operation and functions of the single facer **1** according to the second embodiment will be described below. In the second embodiment, any operation and function other than those of the gap adjustment control according to the adjustment control routine are the same as those in the first embodiment. Thus, only the gap adjustment control will be described below.

<Gap Adjustment Control according to Adjustment Control Routine>

With reference to FIG. **10**, the gap adjustment control according to the adjustment control routine will be described. The gap adjustment controls to be performed by the glue-roll gap adjusting motor control device **400** and the press-roll gap adjusting motor control device **403** are approximate the same. Thus, only the gap adjustment control to be performed by the press-roll gap adjusting motor control device **403** will be described below, as a representative example. FIG. **10** illustrates a relationship between a rotational speed of the servomotor **220** and an elapsed time (second).

Every time the timing instruction is received from the lower-level management device **310**, the press-roll gap adjusting motor control device **403** performs the press-roll gap adjustment control according to the adjustment control routine. When receiving the timing instruction from the lower-level management device **310**, the press-roll gap adjusting motor control device **403** also receives, from the lower-level management device **310**, control instruction information about the press-roll gap adjustment value, the first and second torque values for adjusting a press-roll gap, etc.

First of all, according to the adjustment control routine, the press-roll gap adjusting motor control device **403** operates to rotationally drive the servomotor **220** with a drive current corresponding to the first torque value, until a third wedge-shaped body **217** of a leveling block **215** comes into contact with a wall portion **216**C of a casing **216**, as illustrated in FIG. **4**. When the third wedge-shaped body **217** comes into contact with the wall portion **216**C of the casing **216**, generation of detection pulses from an encoder EC21 is stopped. Then, the press-roll gap adjusting motor control device **403** recognizes the contact of the third wedge-shaped body **217** with the wall portion **216**C, based on the stop of the generation of the detection pulses, and operates to stop of a supply of the drive current to the servomotor **220**. In the state in which the third wedge-shaped body **217** is in contact with the wall portion **216**C, a head of an adjusting screw **221** of a fourth wedge-shaped body **218** of the leveling block **215** illustrated in FIG. **4** is spaced apart from a contact member **212** of a coupling block **211**. In the state in which the head of the adjusting screw **221** is spaced apart from the contact member **212**, a hydraulic pressure of the hydraulic cylinder **47** fully acts to press the press roll **44** against the corrugating roll **23**. The press-roll gap adjusting motor control device **403** also controls drive of the servomotor **240** in the same manner as that for the servomotor **220**, to cause a wedge-shaped body of a leveling block **235** to come into contact with a wall portion of a casing. Thus, the hydraulic pressure of the hydraulic cylinder **48** fully acts to press the press roll **44** against the corrugating roll **23**.

Then, according to the adjustment control routine, the press-roll gap adjusting motor control device **403** operates to rotationally drive the servomotor **220** with the drive current corresponding to the first torque value, until the head of the adjusting screw **221** comes into contact with the contact member **212** of the coupling block **211**. During a time period where the head of the adjusting screw **221** is moved toward the contact member **212**, the press roll **44** vibrates due to periodic contact with ridges of a fluted portion of the upper corrugating roll **23**, and the vibration of the press roll **44** is transmitted to the contact member **212** of the coupling block **211** via a swingable frame **40** and an arm portion **45**. The first torque value is a value of rotation torque of the servomotor **220** set in the same manner as that for the first torque in the first embodiment.

In FIG. **10**, time point TS0 indicates a time point when the drive of the servomotor **220** is started to move the head of the adjusting screw **221** toward the contact member **212**. After the time point TS0, the rotational speed of the servomotor **220** is increased. At time point TS 1 when the head of the adjusting screw **221** starts to come into contact with the contact member **212** being vibrating, the increase of the rotational speed of the servomotor **220** is stopped. When a pressing force of the contact member **212** applied to the head of the adjusting screw **221** becomes larger, the rotational speed of the servomotor **220** is reduced after time point TS2. Subsequently, at time point TS3, the rotation of the servomotor **220** is stopped. The press-roll gap adjusting motor control device **403** recognizes the rotational speed of the servomotor **220**, based on a frequency of the detection pulses from the encoder EC21, and recognizes stop of the rotation of the servomotor **220**, based on stop of the generation of the detection pulses. When recognizing that the rotation of the servomotor **220** is stopped at the time point TS3, the press-roll gap adjusting motor control device **403** reads, from the control time period memory **404**, a control time period CT correlated with a type of paperboard for each of the corrugated medium **10** and the linerboard to be used for an order, such as a thickness of a paperboard. Then, the press-roll gap adjusting motor control device **403** operates to continue to supply the drive current corresponding to the first torque value during the read control time period.

As a result of supplying the drive current to the servomotor **220** during the control time period, the adjusting screw **221** is moved upwardly (in FIG. **4**), and, along with the movement, a vibration amplitude of the contact member **212** is gradually restricted to a small value. When the control time period CT has elapsed, the press-roll gap adjusting motor control device **403** operates to stop the supply of the drive current corresponding to the first torque value to the servomotor **220**.

When the control time period CT has elapsed at time point TSN illustrated in FIG. **10**, the press-roll gap adjusting motor control device **403** operates to store, in an internal temporary memory thereof, a rotation amount by which the servomotor **220** is rotated in a time period from the time point TS0 to the time point TSN, as a reference rotation amount, in correlated relation with an internal temperature of the single facer **1** at the time point TS0. A position of the head of the adjusting screw **221** at the time point TSN is set as a reference position for adjusting a gap between a right end portion of the press roll **44** illustrated in FIG. **2** and the upper corrugating roll **23**.

After the adjusting screw **221** is set at the reference position, the press-roll gap adjusting motor control device **403** operates to rotationally drive the servomotor **220** with a drive current corresponding to the second torque value so as to allow the gap between the press roll **44** and the upper corrugating roll **23** to be increased from a reference gap between the two rolls **44**, **23** at a time when the adjusting screw **221** is located at the reference position, by the press-roll gap adjustment value. The second torque value is a value of rotation torque of the servomotor **220** set in the same manner as that for the second torque value in the first embodiment. The press-roll gap adjustment value is experimentally set in the same manner as that for the press-roll gap adjustment value in the first embodiment.

When rotationally driving the servomotor **220** by a rotation amount corresponding to the press-roll gap adjustment value, the press-roll gap adjusting motor control device **403** operates to stop the rotation of the servomotor **220**. In this case, the adjusting screw **221** moves the contact member **212** upwardly (in FIG. **4**) from the reference position by an amount corresponding to the press-roll gap adjustment value. Thus, the swingable frame **40** is slightly rotated about a pivot shaft **41** in a clockwise direction, and positioned, so that the right end portion of the press roll **44** is positioned with respect to the upper corrugating roll **23**, with a gap equivalent to the press-roll gap adjustment value, therebetween.

The press-roll gap adjusting motor control device **403** also performs control of the servomotor **240** in a parallel way, in the same manner as that for the servomotor **220**. Thus, a head of an adjusting screw of the leveling block **235** is set at a reference position for adjusting a gap between a left end portion (in FIG. **2**) of the press roll **44** and the upper corrugating roll **23**. Subsequently, a swingable frame **42** is slightly rotated about a pivot shaft **43**, and positioned, so that the left end portion of the press roll **44** is positioned with respect to the upper corrugating roll **23**, with a gap equivalent to the press-roll gap adjustment value, therebetween.

As with the press-roll gap adjusting motor control device **403**, the glue-roll gap adjusting motor control device **400** receives, from the lower-level management device **310**, control instruction information about the glue-roll gap adjustment value, the first and second torque values for adjusting a glue-roll gap, etc., and performs control of the servomotors **120**, **140**. Thus, each of the heads of the adjusting screws of the leveling blocks **115**, **135** are set at a reference position for adjusting a gap between a respective one of right and left end portions of the glue roll **30** illustrated in FIG. **2** and the upper corrugating roll **23**. Subsequently, support plate portions **27**, **28** are slightly moved and then positioned, so that each of the right and left end portions of the glue roll **30** is also positioned with respect to the upper corrugating roll **23**, with a gap equivalent to the glue-roll gap adjustment value, therebetween. The glue-roll vibration threshold value is experimentally set in the same manner as that for the glue-roll vibration threshold value in the first embodiment.

<<Effects of Single Facer According to Second Embodiment>>

In the second embodiment, whether or not the maximum rotational speed of the servomotor **220** is reduced to the given rotational speed is determined based on an elapse of the control time period CT after the time point TS3 when the rotation of the servomotor **220** is first stopped, without using a detection device such as an encoder. Thus, there is no need for a processing of detecting the rotational speed of the servomotor **220** in the time period from the time point TS3 to the time point TSN. This makes it easier to set the head of the adjusting screw of each of the leveling blocks at the reference position for adjusting the gap between each of the right and left end portions of the press roll **44** and the upper corrugating roll **23**.

Third Embodiment

With reference to the drawings, a single facer **1** according to a second embodiment of the present invention will be described. In the first embodiment, each of the control devices, for example, the press-roll gap adjusting motor control device **353**, is configured to, based on the detection pulses from the encoder EC21, determine whether or not the maximum rotational speed of the servomotor **220** is reduced to the given rotational speed, to thereby set the head of the adjusting screw of each of the leveling blocks at the reference position for gap adjustment. The third embodiment is different from the first embodiment in that the single facer according to the third embodiment is configured to detect rotation torque of a servomotor, and determine whether or not a state in which the rotation torque reaches a given limit torque has continued for a given time, to thereby set a head of an adjusting screw of each leveling block at a reference position for gap adjustment, as described later, and a press roll **44** in the third embodiment is made of a non-metal material. Thus, only these differences will be described below. In the third embodiment, the same element or component as that in the first embodiment is assigned with the same reference numeral or sign, and its detailed description will be appropriately omitted.

In the third embodiment, upper and lower corrugating rolls **23**, **24** and a glue roll **30** are the same as those in the first and second embodiments. However, a press roll **44** in the third embodiment is made of an elastically deformable non-metal material such as an aramid fiber material.

<<Electrical Configuration>>

With reference to FIGS. **11** and **12**, an electrical configuration of the single facer **1** according to the third embodiment will be described. In particular, the third embodiment is different from the first embodiment in terms of a stored content of a program memory **320** and a configuration of a press-roll gap adjusting motor control device **500**. Thus, the following description will be made with a focus on these differences. FIG. **11** is a block diagram illustrating the electrical configuration of the single facer **1** according to the third embodiment. FIG. **12** is an explanatory diagram illustrating a stored content of a press-roll gap adjustment table **320**B.

The program memory **320** fixedly stores therein programs such as a main control routine of the single facer **1**, an adjustment instruction routine for determining a timing of generating an instruction for a start of gap adjustment control, and fixedly stores therein various preset values. For example, as preset values for the glue roll **30**, the program memory **320** stores therein a hydraulic pressure value for the glue roll **30**, a given glue-roll vibration threshold value, a glue-roll gap adjustment value, and first and second torque values for adjusting a glue-roll gap, in correlated relation with a type of paperboard, such as a raw material, a thickness, a basis weight, etc., of a paperboard, in the same manner as that in the first embodiment. Further, as preset values for the press roll **44**, the program memory **320** stores therein a hydraulic pressure value for the press roll **44**, a given limit torque value, a given duration, and a press-roll gap adjustment value, in correlated relation with a type of paperboard, such as a raw material, a thickness, a basis weight, etc., of a paperboard. The given limit torque value is set to a torque value which fails to overcome a force by which a contact member **212** of a coupling block **211** can press an adjusting screw **221** of a fourth wedge-shaped body **218** of a leveling block **215**, according to a hydraulic pressure of a press hydraulic cylinder **47**. In the second embodiment, the given limit torque value is set to a value equivalent to 30% of a rated torque value of each of two servomotors **220**, **240**. In FIG. **13**, the given limit torque value is indicated by the rotation torque LT. The given duration is a time period in which a rotation torque of each of the servomotors **220**, **240** is maintained at the given limit torque. In FIG. **3**, the given duration is indicated by the time period TD2. A lower-level management device **310** is configured to, among the control instruction information sent from an upper-level management device **300** according to each order, read various preset values correlated with a type of paperboard from the program memory **320**, and send the preset values to each control device. The program memory **320** comprises a glue-roll gap adjustment table **320**A and a press-roll gap adjustment table **320**B. In the third embodiment, the glue-roll gap adjustment value for the glue roll **30** is stored in the glue-roll gap adjustment table **320**A, in correlated relation with a thickness of a corrugated medium **10** in the same manner as that in the first embodiment. On the other hand, the press-roll gap adjustment value for the press roll **44** is stored in the press-roll gap adjustment table **320**B, in correlated relation with a combination of respective basis weights of the corrugated medium **10** and the linerboard **11**. Generally, a thickness of a paperboard becomes larger along with an increase in thickness of the paperboard.

With reference to FIG. **12**, the press-roll gap adjustment table **320**B will be described in detail. In FIG. **12**, each of the basis weight (g/m^2) of the corrugated medium **10** and the basis weight (g/m^2) is classified into five zones: "0 to 120"; "121 to 160"; "161 to 180"; "181 to 200" and "201 or more". The press-roll gap adjustment table **320**B stores therein a large number of press-roll gap adjustment values D11 to D55. Each of the press-roll gap adjustment values is correlated with a combination of one of the basis weight zones of the corrugated medium **10** and one of the basis weight zones of the linerboard **11**. In the third embodiment, as each of the press-roll gap adjustment values, a smaller value is set along with a decrease in basis weight. That is, the press-roll gap adjustment value D11 is set to the smallest value of 0.02 mm, and the press-roll gap adjustment value D55 is set to the largest value of 0.05 mm.

The press-roll gap adjusting motor control device **500** is connected to the lower-level management device **310**, and configured to control a rotation direction and a drive current of each of the servomotors **220**, **240**, according the control instruction information from the lower-level management device **310**. The press-roll gap adjusting motor control device **500** comprises a press-roll gap adjustment instruction unit **501**, and two drive circuits **502**, **503**. Specifically, the press-roll gap adjustment instruction unit **501** is configured to generate an instruction for the rotation direction and the drive current of the servomotor **220**, based on the control instruction information from the lower-level management device **310**, detection pulses from an encoder EC21, and a drive current fed back from the drive circuit **502**. A gap between the press roll **44** and the upper corrugating roll **23** is instructed by the press-roll gap adjustment value from the lower-level management device **310**. Further, the press-roll gap adjustment instruction unit **501** is configured to generate an instruction for the rotation direction and the drive current of the servomotor **240**, based on the control instruction information from the lower-level management device **310**, detection pulses from an encoder EC22, and a drive current fed back from the drive circuit **503**. The press-roll gap adjustment instruction unit **501** fixedly stores in an internal memory **501**A an adjustment control routine to perform press-roll gap adjustment control, wherein it is configured to execute the adjustment control routine according to a timing instruction from the lower-level management device **310**. The press-roll gap adjustment instruction unit **501** is composed of a computer comprising the internal memory **501**A.

When a load applied to each of the servomotors **220**, **240** becomes larger, a drive current to be supplied to the servomotor is increased to generate a rotation torque which can overcome the load. A value of the drive current supplied from the drive circuit **502** (**503**) to the servomotor **220** (**240**) is indicative of a magnitude of the rotation torque of the servomotor **220** (**230**). Thus, a drive current fed back from the drive circuit **502** (**503**) is equivalent to a torque detection signal indicative of the magnitude of the rotation torque of the servomotor **220** (**240**). The press-roll gap adjustment instruction unit **501** is configured to execute the adjustment control routine to thereby instruct the drive circuit **502** (**503**) to supply a drive current to the servomotor **220** (**240**) while allowing a value of the drive current to avoid exceeding a current value corresponding to the given limit torque value.

The drive circuit **502** (**503**) is configured to comprise a current amplifier circuit to control a direction and an amount of a drive current to be supplied to the servomotor **220** (**240**) according to the control instruction information about the rotation direction and the drive current from the press-roll gap adjustment instruction unit **501**. A control device for controlling a rotational position, a rotational speed and a rotation torque of a servomotor as in the press-roll gap adjusting motor control device **500** is commonly known as disclosed, for example, in JP 2006-102889 A.

<<OPERATION AND FUNCTIONS OF SINGLE FACER ACCORDING TO THIRD EMBODIMENT >>

An operation and functions of the single facer **1** according to the third embodiment will be described below. In the third embodiment, any operation and function other than those of the gap adjustment control according to the adjustment control routine executed by the press-roll gap adjusting motor control device **500** are the same as those in the first embodiment. Thus, only the gap adjustment control will be described below.

<Gap Adjustment Control according to Adjustment Control Routine>

With reference to FIG. **13**, the gap adjustment control according to the adjustment control routine executed by the press-roll gap adjusting motor control device **500** will be described. FIG. **13** illustrates a relationship between a rotation torque of the servomotor **220** and an elapsed time (second).

When an operator manually operates an order start button **341**, a glue-application cylinder control device **350** controls a hydraulic pressure of each of two hydraulic cylinders **32**, **33** according to the hydraulic pressure value for the glue roll **30**, in the same manner as that in the first embodiment. Further, a press cylinder control device **351** controls a hydraulic pressure of each of two hydraulic cylinders **47**, **48** according to the hydraulic pressure value for the press roll **44**. During a time period where a specific order is implemented, the hydraulic pressure of each of the hydraulic cylinders **32**, **33** is controlled to be maintained at a constant value, and the hydraulic pressure of each of the hydraulic cylinders **47**, **48** is also controlled to be maintained at a constant value.

Every time the timing instruction is received from the lower-level management device **310**, the press-roll gap adjustment instruction unit **501** performs the press-roll gap adjustment control according to the adjustment control routine. When receiving the timing instruction from the lower-level management device **310**, the press-roll gap adjustment instruction unit **501** also receives, from the lower-level management device **310**, the given limit torque value, the given duration, the press-roll gap adjustment value, etc.

First of all, according to the adjustment control routine, the press-roll gap adjustment instruction unit **501** operates to rotationally drive the servomotor **220** with a drive current corresponding to the given limit torque value, until a third wedge-shaped body **217** of the leveling block **215** illustrated in FIG. **4** comes into contact with a wall portion **216**C of a casing **216**. When the third wedge-shaped body **217** comes into contact with the wall portion **216**C of the casing **216**, generation of the detection pulses from the encoder EC21 is stopped. Then, the press-roll gap adjustment instruction unit **501** recognizes the contact of the third wedge-shaped body **217** with the wall portion **216**C, based on the stop of the generation of the detection pulses, and operates to stop of a supply of the drive current to the servomotor **220**. In the state in which the third wedge-shaped body **217** is in contact with the wall portion **216**C, a head of the adjusting screw **221** is spaced apart from the contact member **212** of the coupling block **211**. In the state in which the head of the adjusting screw **221** is spaced apart from the contact member **212**, the hydraulic pressure of the hydraulic cylinder **47** fully acts to press the press roll **44** against the corrugating roll **23**. The press-roll gap adjustment instruction unit **501** also controls drive of the servomotor **240** in the same manner as that for the servomotor **220**, to cause a wedge-shaped body of a leveling block **235** to come into contact with a wall portion of a casing. Thus, the hydraulic pressure of the hydraulic cylinder **48** fully acts to press the press roll **44** against the corrugating roll **23**.

Then, according to the adjustment control routine, the press-roll gap adjustment instruction unit **501** operates to rotationally drive the servomotor **220** with the drive current corresponding to the given limit torque value, until the head of the adjusting screw **221** of the fourth wedge-shaped body **218** of the leveling block **215** comes into contact with the contact member **212** of the coupling block **211**. During a time period where the head of the adjusting screw **221** is moved toward the contact member **212**, the press roll **44** vibrates due to periodic contact with ridges of a fluted portion of the upper corrugating roll **23**. Vibration of the press roll **44** is transmitted to the contact member **212** of the coupling block **211** via a swingable frame **40** and an arm portion **45**. That is, the adjusting screw **221** is moved toward the contact member **212** being vibrating.

In FIG. **13**, time point TT0 indicates a time point when the drive of the servomotor **220** is started to move the head of the adjusting screw **221** toward the contact member **212**. When the servomotor **220** starts rotating after the time point TT0, a rotation torque of the servomotor **220** is rapidly increased, and then restricted to the given limit torque value. In a situation where the rotation torque of the servomotor **220** is restricted to the given limit torque value, the head of the adjusting screw **221** starts to come into contact with the contact member **212** being vibrating. The time point of the start of the contact is time point TT1.

When a pressing force of the contact member **212** applied to the head of the adjusting screw **221** is reduced, the rotation torque of the servomotor **220** becomes less than the given limit torque value. On the other hand, when the pressing force of the contact member **212** applied to the head of the adjusting screw **221** is increased, the rotation torque of the servomotor **220** is increased toward the given limit torque value. Thus, the rotation torque of the servomotor **220** is repeatedly and alternately reduced from the given limit torque and increased toward the given limit torque. According to the vibration of the press roll **44** caused by rotation of the corrugating rolls **23**, **24**, the above rise and fall of the rotation torque will be repeated in a time period from the time point TT1 to time point TT2.

In the time period from the time point TT1 to time point TT2, when the contact member **212** being vibrating is temporarily moved away from the head of the adjusting screw **221** according to the vibration of the press roll **44**, or when the pressing force of the contact member **212** applied to the head of the adjusting screw **221** is reduced, the head of the adjusting screw **221** is moved upwardly (in FIG. **4**). Even when the head of the adjusting screw **221** receives a large pressing force from the contact member **212**, a position of the head of the adjusting screw **221** after the movement is held by a function of the leveling block **215**, so that the servomotor **220** is kept from being reversely rotated.

Along with the upward movement (in FIG. **4**) of the adjusting screw **221** according to the rotation the servomotor **220**, the vibration amplitude of the contact member **212** is gradually restricted to a smaller value. The press-roll gap adjustment instruction unit **501** repeatedly determines whether or not a duration of a state in which the rotation torque of the servomotor **220** is restricted to the given limit torque, after the start of the rotation of the servomotor **220** at the time point TT0, has reached a given duration TD2. Just after the start of the rotation of the servomotor **220**, the rotation torque of the servomotor **220** is restricted to the given limit torque value for a time TD **1**. However, in the third embodiment, the given duration TD2 is greater than the duration TD **1**. The given duration TD2 is set to a value sufficiently longer than a period of vibration occurring in the corrugating rolls **23**, **24**, which is measured through experiment in a situation where a single-faced corrugated paperboard **12** is produced under a condition that a rotational speed of each of the corrugating rolls **23**, **24** is set to the slowest value.

When the head of the contact member **212** comes into contact with the adjusting screw **221** in a state in which the vibration amplitude of the contact member **212** is restricted to a relatively small value, a relatively large pressing force is continually applied to the head of the contact member **212**. Thus, a time period in which the rotation torque of the servomotor **220** is restricted to the given limit torque value is extended. When the press-roll gap adjustment instruction unit **501** determines that the time period of the restricted state reaches the given duration TD2, it instructs the drive circuit **502** to stop the supply of the drive current to the servomotor **220**.

Further, after the determination on the elapse of the given duration TD2, the press-roll gap adjustment instruction unit **501** operates to store, in an internal temporary memory thereof, a rotation amount by which the servomotor **220** is rotated in a time period from the time point TT0 to the time point TT2, as a reference rotation amount, in correlated relation with an internal temperature of the single facer **1** at the time point TT0. A position of the head of the adjusting screw **221** at the time point TT2 is set as a reference position for adjusting a gap between a right end portion of the press roll **44** illustrated in FIG. **2** and the upper corrugating roll **23**. When the reference rotation amount stored this time is different from a reference rotation amount stored last time, by a given amount or more, there is a possibility that abnormality occurs, for example, in the contact between the contact member and the adjusting screw. Thus, in such a situation, an error message may be indicated or displayed.

After the adjusting screw **221** is set at the reference position, the press-roll gap adjustment instruction unit **501** operates to rotationally drive the servomotor **220** with a drive current corresponding to a torque value equal to or less than the given limit torque value so as to allow the gap between the press roll **44** and the upper corrugating roll **23** to be increased from a reference gap between the two rolls **44**, **23** at a time when the adjusting screw **221** is located at the reference position, by the press-roll gap adjustment value.

When rotationally driving the servomotor **220** by a rotation amount corresponding to the press-roll gap adjustment value, the press-roll gap adjustment instruction unit **501** operates to stop the rotation of the servomotor **220**. In this case, the adjusting screw **221** moves the contact member **212** downwardly (in FIG. **4**) from the reference position by an amount corresponding to the press-roll gap adjustment value. Thus, the swingable frame **40** is slightly rotated about a pivot shaft **41** in a counterclockwise direction, and positioned, so that the right end portion of the press roll **44** is positioned with respect to the upper corrugating roll **23**, with a gap reduced from the reference position by the press-roll gap adjustment value, therebetween.

The press-roll gap adjustment instruction unit **501** also performs control of the servomotor **240** in a parallel way, in the same manner as that for the servomotor **220**. Thus, a head of the adjusting screw of the leveling block **235** is set at a reference position for adjusting a gap between a left end portion (in FIG. **2**) of the press roll **44** and the upper corrugating roll **23**. Subsequently, the swingable frame **42** is slightly rotated about a pivot shaft **43**, and positioned, so that the left end portion of the press roll **44** is positioned with respect to the upper corrugating roll **23**, with a gap reduced from the reference position by the press-roll gap adjustment value, therebetween.

<<Effects of Single Facer According to Third Embodiment>>

In the third embodiment, in order to detect the rotation torque of the servomotor **220** (**240**) the press-roll gap adjusting motor control device **500** is provided with a circuit for feeding back a drive current supplied from the drive circuit **502** (**503**), to the press-roll gap adjustment instruction unit **501**, wherein the fed-back drive current is utilized to detect the magnitude of the vibration occurring in the press roll **44**, so that it is not necessary to provide a special vibration detection device in the vicinity of the press roll **44**. Generally, such a special vibration detection device is likely to confront a problem of difficulty in accurately detecting the magnitude of the vibration of the processing roll (press or glue roll), because it is exposed to high temperatures and floating dust inside the single facer **1**. In contrast, providing the circuit for feeding back a drive current to be supplied to the servomotor makes it possible to accurately detect the vibration of the processing roll.

[Correspondence Relationship Between Elements in Appended Claims and Embodiments]

The single facer **1** is one example of “single facer” set forth in the appended claims. The corrugating roll **23** (**24**) is one example of “corrugating roll” set forth in the appended claims, and the upper corrugating roll **23** is one example of “specific corrugating roll” set forth in the appended claims. The glue roll **30** or the press roll **44** is one example of “processing roll” set forth in the appended claims. The support plate portions **27**, **28** or the swingable frames **40**, **42** are one example of “supporting mechanism” set forth in the appended claims, and one example of “first and second supporting mechanisms” set forth in the appended claims. The swingable frame **40** (**42**) is one example of “swingable member” set forth in the appended claims. The glue-application hydraulic cylinders **32**, **33** or the press hydraulic cylinders **47**, **48** are one example of “pressing actuator section" set forth in the appended claims. The leveling blocks **115**, **135** or the leveling blocks **215**, **235** are one example of "restricting mechanism" set forth in the appended claims, and one example of "first and second restricting mechanisms" set forth in the appended claims. The wedge-shaped body **117** (**217**) is one example of "movable member" set forth in the appended claims, and a combination of the wedge-shaped body **118** (**218**) and the adjusting screw **121** (**221**) is one example of "restriction member" set forth in the appended claims. The externally-threaded shaft **119** (**219**) is one example of "threaded shaft" set forth in the appended claims. The servomotors **120**, **140** or the servomotors **220**, **240** are one example of "motor" set forth in the appended claims, and one example of "first and second motors" set forth in the appended claims. The glue-roll gap adjusting motor control device **352** (**400**) or the press-roll gap adjusting motor control device **353** (**404**, **500**) is one example of "control section" set forth in the appended claims. The encoders EC 11, EC12 or the encoders EC 21, EC22 is one example of "detection device configured to detect a rotational change amount" set forth in the appended claims, and one example of "first and second detection devices" set forth in the appended claims. The circuits for feeding back a drive current from the drive circuits **502**, **503** to the press-roll gap adjustment instruction unit **501** is one example of "detection device configured to detect a rotation torque" set forth in the appended claims, and one example of "first and second detection devices" set forth in the appended claims. The control processing to be executed by the glue-roll gap adjusting motor control device **352** (**400**) or the press-roll gap adjusting motor control device **353** (**403**), wherein the servomotors **120**, **140** or the servomotors **220**, **240** are driven with the first torque value in such a manner as to allow each of the heads of the adjusting screws of the leveling blocks to be set at the reference position for adjusting the gap between each of the right and left end portions of the glue or press roll **30** or **44** and the upper corrugating roll **23**, is one example of "first control processing" set forth in the appended claims. The control processing to be executed by the glue-roll gap adjusting motor control device **352** (**400**) or the press-roll gap adjusting motor control device **353** (**403**), wherein the servomotors **120**, **140** or the servomotors **220**, **240** are driven with the second torque value in such a manner as to allow each of the right and left end portions of the glue roll **30** or each of the right and left end portions of press roll **44** to be positioned with respect to the upper corrugating roll **23**, with a gap increased from the reference position by the glue-roll gap adjustment value or the press-roll gap adjustment value, therebetween, is one example of "second control processing" set forth in the appended claims. The control processing to be executed by the press-roll gap adjustment instruction unit **501** of the press-roll gap adjusting motor control device **500**, wherein the servomotors **220**, **240** are driven in such a manner as to allow the rotation torque of each of the servomotors **220**, **240** to be restricted to the given limit torque value, thereby allowing each of the heads of the adjusting screws of the leveling blocks **215**, **235** to be set at the reference position for adjusting the gap between each of the right and left end portions of the press roll **44** and the upper corrugating roll **23**, is one example of "first control processing" set forth in the appended claims. The control processing to be executed by the press-roll gap adjustment instruction unit **501**, wherein the servomotors **220**, **240** are driven in such a manner as to allow each of the right and left end portions of press roll **44** to be positioned with respect to the upper corrugating roll **23**, with a gap reduced from the reference position by the press-roll gap adjustment value, therebetween, is one example of "second control processing" set forth in the appended claims.

[Modification]

While the present invention has been described based on the embodiments thereof, it is obvious to those skilled in the art that various changes and modifications may be made therein without departing from the spirit and scope thereof as set forth in appended claims.

(1) In all of the above embodiments, the glue roll **30** or the press roll **44** is used as one example of a processing roll configured to be pressed against the upper corrugating roll **23** through the corrugated medium **10** or through the corrugated medium **10** and the liner **11**. However, the present invention is not limited to such processing rolls. For example, the processing roll may be any other type as long as it is configured to be pressed against either one of two corrugating rolls, and has a need for adjusting a gap with respect to the corrugating roll.

(2) In the third embodiment, the press roll **44** is made of a non-metal material such as an aramid fiber material, which has elasticity greater than that of chromium molybdenum steel as a material for the corrugating roll. However, the press roll **44** may be made of any non-metal material other than an aramid fiber material. For example, the press roll may be made of silicone rubber. When silicone rubber is used as a material for the press roll, silicone rubber has elasticity greater than that of an aramid fiber material. Specifically, a compressive strength (Young's modulus) of silicone rubber has a small value of about 1/300 of a compressive strength (Young's modulus) of an aramid fiber material. When the press roll is pressed against the upper corrugating roll through a corrugated medium and a linerboard, the corrugated medium and the linerboard are compressed, and the press roll is also compressed. The press roll can be made of an elastically deformable non-metal material such as silicone rubber so as to suppress the formation of a press mark during production of a single-faced corrugated paperboard. In the case where the press roll is made of an elastically deformable non-metal material, it is necessary to more accurately set the gap between the press roll and upper corrugating roll. In this case, the gap between the press roll and upper corrugating roll can be accurately set by positioning the adjusting screw equivalent to "restriction member" set forth in the appended claims, at the reference position. In the case where the press roll is made of an elastically deformable non-metal material such as silicone rubber, the control processing for changing the gap between the press roll and upper corrugating roll according to the press-roll gap adjustment value, after the head of the adjusting screw of each of the leveling blocks is positioned at the reference position is not executed. That is, when the head of the adjusting screw of each of the leveling blocks is positioned at the reference position, the head of the adjusting screw is held at the reference position.

(3) In the third embodiment, the glue roll **30** is made of a metal material such as carbon steel, and the press roll **44** is made of a non-metal material such as an aramid fiber material, which has elasticity greater than that of chromium molybdenum steel as a material for the corrugating roll. However, the present invention is not limited to such a combination. For example, the glue roll **30** may be made of a non-metal material such as an aramid fiber material, which has elasticity greater than that of chromium molybdenum steel as a material for the corrugating roll, and the press roll **44** may be made of a metal material such as carbon steel. Alternatively, both of the glue roll **30** and the press roll **44**

may be made of a non-metal material such as an aramid fiber material, which has elasticity greater than that of chromium molybdenum steel as a material for the corrugating roll. In the modification where the glue roll **30** is made of a non-metal material such as an aramid fiber material, the glue-roll gap adjustment value for the glue roll **30** is stored in the glue-roll gap adjustment table **320**A of the program memory **320**. In the modification where the press roll **44** is made of a non-metal material such as an aramid fiber material, the glue-roll gap adjustment value and the press-roll gap adjustment value are set through experiment, depending on goodness of laminating conditions for the corrugated medium **10** and the linerboard **11** of the single-faced corrugated paperboard **12**. The goodness of laminating conditions has a meaning including an amount of glue to be applied to the corrugated medium.

(4) In the second embodiment, the gap adjustment control is configured such that the time period from the time point TS0 to the time point TS3 and the rotational speed of the servomotor **220** are detected by the encoder EC21, and it is determined whether or not the control time period CT has elapsed from the time point TS3 when the servomotor **220** is first stopped, as illustrated in FIG. **10**. However, the present invention is not limited to this configuration. For example, the gap adjustment control may be configured such that the time period from the time point TS0 to the time point TSN is preliminarily and experimentally measured with respect to each type of paperboard for each of a corrugated medium and a linerboard, such as each thickness of a paperboard, and stored in a storage section, whereafter one time period corresponding to a type of paperboard for each of a corrugated medium and a linerboard for implementing an order is read from the storage section and the servomotor is continually driven during the read time period. Alternatively, the gap adjustment control may be configured such that the rotation amount by which the servomotor is rotated in the time period from the time point TS0 to the time point TSN is preliminarily and experimentally measured, and stored in a storage section, whereafter one rotation amount corresponding to a type of paperboard for each of a corrugated medium and a linerboard for implementing an order is read from the storage section, and the servomotor is continually driven by the read rotation amount.

(5) In all of the above embodiments, the gap adjustment apparatus **100** (**200**) is configured to allow the adjusting screw **121** (**221**) provided in the leveling block to come into contact with the contact member **112** (**212**) coupled to a member supporting the glue roll **30** (press roll **44**). However, the present invention is not limited to this configuration. For example, the gap adjustment apparatus may be configured such that an adjusting screw is provided in a member capable of being linearly moved according to a contact with an eccentric cam being rotationally driven by a servomotor, wherein the adjusting screw is configured to come into contact with the contact member. Alternatively, as disclosed, for example, in the JP 58-042025 B, the gap adjustment apparatus may be configured to comprise a leveling block having a pair of wedges whose relative positions can be changed by a motor, wherein an eccentric member supporting a processing roll is moved by a movement of the leveling block.

(6) In the first embodiment, the gap adjustment apparatus is configured such that the magnitude of the vibration occurring in the glue roll **30** or the press roll **44** is detected by the encoder EC11 (EC12) or the encoder EC 21 (EC 22) in the form of a rotational speed change amount in the servomotor **120** (**140**) or the servomotor **220** (**240**), as illustrated in FIG. **8**. However, the present invention is not limited to this configuration. For example, the gap adjustment apparatus may be configured such that a vibration detection device is disposed in adjacent relation to a processing roll or a member supporting the processing roll, wherein the servomotor is driven until a magnitude of vibration detected by the vibration detection device is reduced to a given value, and a gap between the processing roll and the upper corrugating roll is adjusted on the basis of a reference position defined as a position of the adjusting screw at a time when the magnitude of the vibration becomes the given value. In this modification, until the magnitude of the vibration is reduced to the given value, the servomotor may be driven by a drive current corresponding to either one of the first torque value and the second torque value.

(7) In all of the above embodiments, the lower-level management device **310** is configured such that the interval of generation of the timing instruction is extended as the internal temperature of the single facer **1** is increased toward the reference temperature TRF, as illustrated in FIG. **7**. However, the present invention is not limited to this configuration. For example, the lower-level management device may be configured to generate the timing instruction at even intervals during a time period in which the internal temperature of the single facer **1** is increased toward the reference temperature TRF, and stop generating the timing instruction as long as the internal temperature of the single facer **1** falls within a given temperature fluctuation range on the basis of the reference temperature TRF.

(8) In the first and second embodiments, the press-roll gap adjustment value is a value obtained by subtracting a total thickness of the corrugated medium **10** and the linerboard **11** at a time when the corrugated medium **10** and the linerboard **11** are compressed by a compression force corresponding to a pressing force applied from the contact member **212** to the adjusting screw **221** when the adjusting screw **221** is located at the reference position, from a total thickness of the corrugated medium **10** and the linerboard **11** in an uncompressed state, and set experimentally. However, the press-roll gap adjustment value may be set in a different manner. For example, the press-roll gap adjustment value may be a value obtained by subtracting a total thickness of the corrugated medium **10** and the linerboard **11** at a time when the corrugated medium **10** and the linerboard **11** are compressed by a compression force corresponding to a pressing force applied from the contact member **212** to the adjusting screw **221** when the adjusting screw **221** is located at the reference position, from a total thickness of the corrugated medium **10** and the linerboard **11** at a time when the corrugated medium **10** and the linerboard **11** are uncompressed by a compression force corresponding to a pressing force sufficiently smaller than that at the reference position, and set experimentally. The glue-roll gap adjustment value may be set in the same manner as that for the press-roll gap adjustment value.

(9) In the first embodiment, the gap adjustment apparatus is configured such that the magnitude of the vibration occurring in the glue roll **30** or the press roll **44** is detected by the encoder EC11 (EC12) or the encoder EC 21 (EC 22) in the form of a rotational speed change amount in the servomotor **120** (**140**) or the servomotor **220** (**240**). In the third embodiment, the gap adjustment apparatus is configured such that the magnitude of the vibration occurring in the glue roll **30** or the press roll **44** is detected by the circuit for feeding back a drive current supplied from the drive circuit **502** (**503**), to the press-roll gap adjustment instruction unit **501**, in the form of the rotation torque of the servomotor

120 (140) or the servomotor 220 (240). However, the detection device for detecting the magnitude of the vibration occurring in the glue roll 30 or the press roll 40 is not limited to the configurations in the first to third embodiments. For example, the detection device may be configured to detect a pressure acting between the movable portion of the supporting mechanism and the restriction member, as vibration occurring in a processing roll, by a load sensor such as a load cell, and the control section may be configured to drive the servomotor until a state in which a pressure detected by the detection device is increased to a given pressure continues for a given time. In this modification, the given pressure and the given time is predetermined by an experiment. In this case, the pressure acting between the movable portion of the supporting mechanism and the restriction member is detected as vibration occurring in a processing roll, so that it is not necessary to install a gap detection sensor in adjacent relation to the corrugating roll as in conventional single facers.

What is claimed is:

1. A single facer for producing a single-faced corrugated paperboard by forming a corrugated medium and gluing a linerboard onto the corrugated medium, comprising:

a pair of corrugating rolls configured to be rotatable to form the corrugated medium;

a press roll configured to be rotatable around a rotation center of the press roll;

a swingable frame configured to support the press roll for swing motion around a swing center away from the rotation center;

a press cylinder configured to press the press roll to swing in a direction for pressing the corrugated medium against one of the pair of corrugating rolls,

wherein the swingable frame vibrates, along with the press roll, around the swing center as the corrugated medium passes between the press roll and the one of the pair of corrugating rolls;

a restricting mechanism comprising a adjusting screw configured to be movable towards or away from the swingable frame, the restricting mechanism being operable to move the adjusting screw to come in contact with the swingable frame to restrict oscillation vibration of the swingable frame and the press roll that occurs as the corrugated medium passes between the press roll and the one of the pair of corrugating rolls;

a motor drive circuit configured to drive a motor to apply a motor torque to the adjusting screw to urge the adjusting screw against the swingable frame and detect vibration of the motor torque of the motor based on a motor current flowing through the motor; and

a press roll gap adjustment instruction circuit programmed to execute a first control processing which comprises driving the motor to perform constant motor torque control on the motor torque so that the adjusting screw is pressed against the swingable frame while being in contact with the swingable frame,

wherein the adjusting screw makes an advance to push the swingable frame at every cycle of the vibration of the swingable frame so that a magnitude of the vibration of the swingable frame progressively decreases at every cycle of the vibration, and

the press roll gap adjustment instruction circuit further programmed to monitor the vibration detected by the motor drive circuit and operate the motor to cease application of the motor torque on the adjusting screw when the detected vibration becomes smaller than a predetermined magnitude.

2. The single facer according to claim 1, wherein the press roll gap adjustment instruction circuit is further programmed to execute a second control processing which comprises:

defining a position of the adjusting screw as a reference position of the adjusting screw when the detected vibration becomes smaller than the predetermined magnitude; and

driving the motor to move the swingable frame until a gap between the press roll and the one of the pair of corrugating rolls becomes equal to a given adjustment value.

3. The single facer according to claim 2, wherein the press roll is made of a non-metal material, and the given adjustment value is determined based on a combination of respective properties of the corrugated medium and the linerboard or based on a property of the corrugated medium.

4. The single facer according to claim 1, wherein the press roll is a press roll made of a non-metal material having elasticity greater than that of the one of the pair of corrugating roll.

5. The single facer according to claim 1, wherein the restricting mechanism further comprises:

an externally-threaded shaft configured to be rotated by the motor;

a first movable member formed to have a first inclined surface, the first movable member being threadingly engaged with the externally-threaded shaft, wherein rotation of the externally-threaded shaft moves the first movable member in a length direction of the externally-threaded shaft; and

a second movable member formed to have a second inclined surface being in sliding contact with the first inclined surface of the first movable member, wherein the sliding contact between the first and second inclined surfaces of the first and second movable members is operable to translate rotation of the externally-threaded shaft into movement of the adjusting screw in a direction perpendicular to the length direction of the externally-threaded shaft.

6. The single facer according to claim 1, wherein

the adjusting screw is situated such that a distance between the adjusting screw and the swing center is longer than a distance between the swing center and the rotation center of the press roll.

7. A single facer for producing a single-faced corrugated paperboard by forming a corrugated medium and gluing a linerboard onto the corrugated medium, comprising:

a pair of corrugating rolls configured to be rotatable to form the corrugated medium;

a press roll configured to be rotatable around a rotation center of the press roll;

first and second swingable frames configured to support opposite ends of a rotary shaft of the press roll so that the press roll swings around a swing center away from the rotation center;

a press cylinder configured to press the press roll to swing in a direction for pressing the corrugated medium against one of the pair of corrugating rolls,

wherein the first and second swingable frames vibrate, along with the press roll, around the swing center as the corrugated medium passes between the press roll and the one of the pair of corrugating rolls;

first and second restricting mechanisms provided, respectively, for the first and second swingable frames, each of the first and second restricting mechanisms comprising a adjusting screw configured to be movable towards or away from a corresponding one of the first and second swingable frames, the first and second restricting mechanisms being operable to move their adjusting screws to come in contact, respectively, with the first and second swingable frames to restrict vibration of the first and second swingable frames and the press roll that occurs as the corrugated medium passes between the press roll and the one of the pair of corrugating rollers;

first and second motors driven to apply a torque to the first and second adjusting screws to urge the first and second swingable frames, respectively, against the first and second swingable frames;

first and second motor drive circuits provided, respectively, for the first and second restricting mechanisms and configured to drive first and second motors, respectively, to apply a motor torque to the first and second adjusting screws to urge the first and second adjusting screws, respectively, against the first and second swingable frames and detect vibration of the motor torque of the first and second motors based on motor current flowing through the first and second motors; and

a press roll gap adjustment instruction circuit programmed to execute a first control processing which comprises driving the first and second motors to perform constant motor torque control on the motor torque so that the first and second adjusting screws are pressed, respectively, against the first and second swingable frames while being in contact, respectively, with the first and second swingable frames,

wherein the first and second adjusting screws make an advance to push the first and second swingable frames, respectively, at every cycle of the vibration of the first and second swingable frames so that a magnitude of the vibration of the first and second swingable frames progressively decreases at every cycle of the vibration, and

the press roll gap adjustment instruction circuit further programmed to monitor the vibration detected by the first and second motor drive circuits and operate the first and second motors to cease application of the motor torque on the first and second adjusting screws when the detected vibration becomes smaller than a predetermined magnitude.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 10,751,966 B2
APPLICATION NO. : 14/473278
DATED : August 25, 2020
INVENTOR(S) : Hisashi Hayashi et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

In Column 41, Claim 1, Line 42, delete “oscillation”.

Signed and Sealed this
Twentieth Day of October, 2020

Andrei Iancu
Director of the United States Patent and Trademark Office